For Editorial Contents see page 545

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TELEGRAM-FORM CONVEYING SYSTEMS; GENERAL POST OFFICE—III.*

IN the first two articles of the series on the different types of telegram-form conveying systems employed by the General Post Office, the pneumatic-tube system was briefly outlined, particularly as applied to the Central Telegraph Office, London. It is now proposed to describe it in more detail, but it should be mentioned at the outset that the pneumatic transmission of messages is practised in large provincial post offices also. The tubes at all offices are of two types, viz., street tubes and house tubes. Street tubes are used for the transmission of telegram forms from busy branch offices to the head or central office, whence they are telegraphed in accordance with the address they carry. In the return direction they are used to send messages to offices for local delivery. Pneumatic-tube transmission provides very much quicker handling of the messages since, instead of their having to be telegraphed or telephoned to the central dispatching office, the forms as filled in by the public can be sent off in batches every few seconds. Moreover, as the actual forms are passed on to the dispatching office, the possibility of error due to double handling by voice or wire is eliminated. The street tube, as was explained on page 375, *ante*, is also used to connect the offices of cable companies, newspapers, etc., with the Central Telegraph Office, thus relieving possible congestion at the local post offices.

House tubes are used in two main ways. They form internal extensions of the street tubes in the central office and are employed also in the transmission of forms from one part of a building to another; as from a counter in a public office to the dispatching room in that office. There is another important use of pneumatic transmission, apart from its employment in handling telegram forms. This is concerned with the working of large telephone trunk exchanges. Details of the calls received are written on tickets which have to be passed either from one operator to another or to a filing position. Ultimately, all such tickets are sorted so that any inquiry that may arise in connection with a particular call can be dealt with promptly. The rapidity of operation in the pneumatic tubes used in the telephone exchanges is, perhaps, even more marked than with those used in the telegraph offices, since, in the latter, the messages have to be inserted in a carrier to begin their journey and to be taken from the carrier on its completion. The telephone ticket, on the other hand, is transmitted without a carrier, the rear portion of the ticket being simply bent up to form a sail upon which the positive air pressure or the vacuum-induced air pressure acts as a propellant. Naturally, the construction of the carrier tubes and the ticket tubes differs materially, since the former are of circular and the latter of rectangular cross-section. The street and house carrier tubes vary in minor details only.

The carrier tubes will be dealt with first, the ticket tubes being described subsequently. Carrier tube systems are by no means invariably identical. They may differ, for instance, in bore, for, although this is generally 2¼ in., tubes of 3-in. bore, and, occasionally, 1½-in. bore, are also used, the size depending on the conditions of the traffic to be carried. The tube is, of course, air-tight throughout its length, and is made very smooth internally in order to keep to a minimum the friction between the wall of the tube and the carrier, and that of the column of air which moves with the carrier. The propelling air must be kept in motion, the carriers being introduced into the flow as required. Pneumatic transmission is, thus, roughly analogous to the transport of articles by depositing them on a continuously-moving belt as opposed to driving the carriers by an expanding puff of air, such as is employed to project a missile from an air gun. The air stream is set up in the tubes either positively, by pumping air under pressure into the starting end of the tubes, or negatively, by exhausting air at the delivery end of the tubes; in this case part of the atmospheric pressure is utilised as the propellant. The selection of either system is a matter of convenience rather than one of inherent advantage. Thus, pressure working is used for sending the carriers to the branch offices from the central office, viz., "down" traffic, while the same plant provides vacuum working to send them in the reverse direction, viz., "up" traffic.

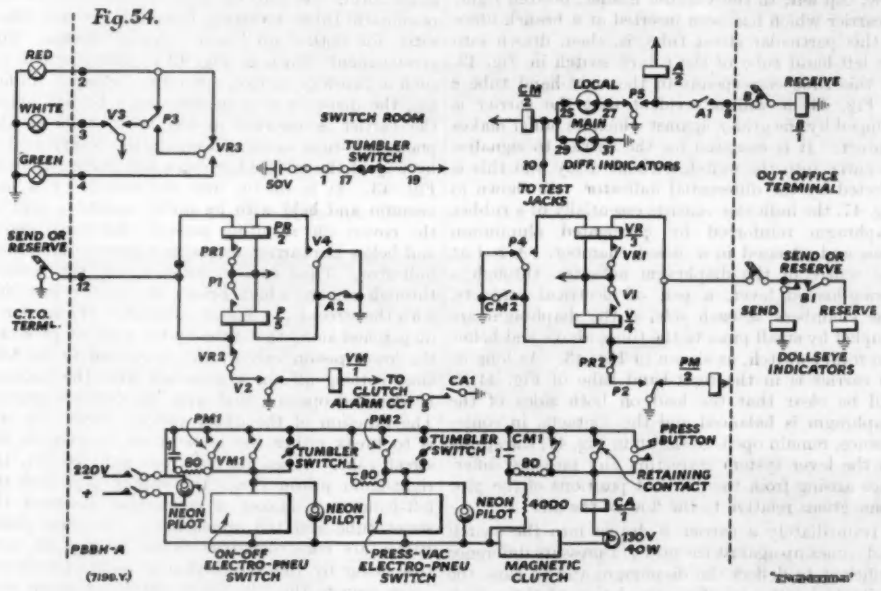
The particular system adopted depends largely on local conditions. It would obviously be uneconomical, for example, to have pumping plant installed at all the 67 branch offices connected by street tubes to the Central Telegraph Office in London, which plant would be needed if pressure working were employed for the "up" messages. As it is, in London, the pumping plant is all situated at the Central Telegraph Office, with the exception of the West-End sub-centre, which has a small installation of its own. The pneumatic tubes radiating from the Central Telegraph Office and from the West-End sub-centre vary in nature according to the volume of the traffic involved. Where this is large, there are separate tubes for the "up" and "down" streams, but in most cases a single tube only is installed, "up" traffic and "down" traffic being worked alternately in this one tube. The standard air pressure is 10 lb. per square inch gauge, or 24·7 lb. per square inch absolute, for street tubes, although in certain cases 12 lb. per square inch may be necessary. With vacuum-induced transmission the standard is a degree of vacuum such that a following pressure of 6·7 lb. per square inch below atmosphere, *i.e.*, 8 lb. per square inch absolute, is created. Since the tubes vary in length from a few hundred feet to over three miles, the actual pressure required in any particular case is largely based on carrying capacity, a transit speed of 30 ft. per second, or approximately 20 m.p.h., being taken as a standard.

In order to obtain this speed with the pressures mentioned above, the 2¼-in. bore tube must not exceed 7,000 ft. in length while the 3-in. bore tube is limited to 10,000 ft. Hence the necessity for higher pressures for long-distance tubes unless the traffic demands are such that a slower transit speed than the standard would be satisfactory. Every case has to be treated on its merits and too many factors are concerned to make it possible to give specific examples. The Post Office engineers have, however, constructed curves which enable any new installation to be rapidly designed. The pressure can, of course, be varied to suit individual tubes fed from a common source by means of throttle valves. In connection with carrying capacity, it may be mentioned that the carrier for the 2¼-in. bore tube will hold up to 25 telegram forms. It is not generally necessary to wait for one carrier to be received at the distant end before the next is dispatched, as the tubes are provided with signalling devices which enable successive carriers to be dispatched with definite space intervals or definite time intervals between them, according to the type of device used, thus avoiding considerable delay in the case of long tubes. The pressure or vacuum is maintained continuously in this method of working. Conversely, during slack periods, the air supply can be used intermittently with resultant economy.

The second of our previous accounts included, on page 431, *ante*, some brief references to the pneumatic-tube table in the Inland Telegram Room of the Central Telegraph Office, London. A view of this table is given in Fig. 40, Plate XXIX, in this issue. As shown in Fig. 15, Plate XXIII, *ante*, the table lies along the outer wall of that portion of the room allocated to the circulation tables, addressing tables, and so forth. It serves for both incoming and outgoing traffic. The incoming traffic consists of carriers containing telegram forms coming from the larger branch post offices in the London telephone area, and from the offices of cable companies, newspapers, news agencies, etc. The carriers reach the table through the straight tubes seen in the background of Fig. 40 and fall into discharge terminals the tops of which are just visible above the partitioned wooden trays. Each terminal consists of a somewhat bottle-shaped cast-iron box standing on end and divided vertically by a diaphragm and grid which both curve at the bottom towards a spring-loaded flap on the flat front face of the box. The flap is hinged at its top edge and is of aluminium with a soft leather seating face. The falling carrier is deflected by the grid and, by its momentum, pushes open the flap and is discharged. The spring then automatically closes the flaps and the exhaust air escapes to the atmosphere by way of a common box on which all the terminals are seated.

The carriers fall on to a conveyor on the table top. The conveyor, however, is not visible in the illustration, though its position is indicated by the white tubular buffer seen underneath the tray. The conveyor consists of two belts in line, one belt being reversible so that the whole of the carriers can be taken to one end of the table or one half of them to each end, as may be desired. The belts are 9 in. wide and run at a speed of 100 ft. per minute. The carriers are removed from the conveyor as they reach the ends of the table, the telegram forms being immediately extracted and being placed in a drag-band conveyor, of which there is one at each end of the table. These conveyors carry the forms to the primary circulation table, from which they are distributed as previously explained. The carriers consist of a gutta-percha cylinder closed at one end by a felt pad which also serves as a buffer and a packing ring. The body of the cylinder has a felt jacket extending beyond the open end in the form of a skirt. The felt pad, when new, is only $\frac{1}{32}$ in. less in diameter than the

Fig. 54.



* Part I of this series appeared on page 375, *ante*, and Part II on page 429, *ante*.

bore of the tube. The body of the carrier has more clearance but, as the direction of travel is buffer first, the pressure of the air swells out the skirt, making what is virtually an air-tight seal. The surface in contact with the tube is only that due to the edge of the seal and that of the buffer. The telegram forms are rolled up and held inside the carrier by an elastic band. The overall length of a 2¼-in. tube carrier is 6¾ in. It will carry 25 plain telegram forms or 12 enveloped forms.

Returning to consideration of the pneumatic-tube table, Fig. 40, it should be here noted that the curved tubes alternating with the straight tubes are for dispatching carriers. They are under vacuum and the insertion of a carrier in the bell-mouthed end opens a flap so that the carrier is drawn in. The outgoing carriers contain, in the main, enveloped telegram forms which are delivered by hand to the pneumatic-tube table operator as already explained. Both the straight receiving tubes and the curved dispatching tubes seen in Fig. 40 are not, as might be imagined, parts of the street tubes, but are house tubes connected to the street tubes through electrically-operated rotary switches. These switches are automatic and it is their installation, which entirely eliminates the delays possible in manual handling, that differentiates the pneumatic-tube installation at the Central Telegraph Office from those elsewhere. A view of the switch room, situated in this office, is given in Fig. 41, Plate XXIX, while the illustrations Figs. 42 to 47, on the same Plate, give some details of the mechanisms employed. In the first place, it must be understood that although the rotary switches divert the carriers, automatically-controlled valves are necessary to change the tubes over from pressure to vacuum and *vice versa*, and that the pressures and vacua required for the house tubes are not nearly so high as those necessary for the street tubes, the house tubes being, obviously, relatively short.

Of the several supply headers, the street tube pressure and vacuum headers are not visible in Fig. 41, but their positions can be identified by the assemblages of valves, tee-pieces, etc., in the centre background, the nature of these assemblages being shown in Figs. 42 and 43. The former gives some idea of the construction of one of the automatic control valves and the latter shows, diagrammatically, that two of the double valves, Fig. 42, are required for each switch on a tube having both "up" and "down" traffic. Sectional views of a rotary switch are given in Figs. 44 and 45, while an external view is given in Fig. 51. This latter view will enable the position of the rotary switches to be recognised in Fig. 41, from which view it will be evident that near each row of switches is a panel carrying various electrical devices and surmounted by a pair of rectangular steel headers. These headers provide the low pressure and low vacuum for the operation of the house tubes. A single section of a panel is shown in Fig. 52, at the bottom of which view a shaft running parallel to the panel is visible. This shaft can also be distinguished in Fig. 41. It terminates in a covered bevel gear with its pinion mounted on a cross-shaft driven, through reduction gear, by one or other of the motors seen in the foreground. The panel shafts, one to each row of rotary switches, are driven continuously and the switches are automatically coupled to them when rotation is required. A simplified diagram of the electrical circuits is given in Fig. 46, while Fig. 47 shows a sectional view of the differential indicators seen near the lower edge of the panel in Fig. 52.

The main components of the rotary-switch installation having been identified some account of its operation may now be given. Perhaps consideration of the rotary switch itself, as shown in Figs. 44 and 45, is the most convenient starting point. A cylindrical frame *a*, with gaps in its wall, is bolted to a base *b* and a cover *c*, both of which are recessed to receive an inner cylinder *d*. The inner cylinder carries three tubes *e*, which are of the same bore as the street and house tubes and are connected to the base and cover in line with those tubes. The centres of the tubes are arranged, in plan, in an equilateral triangle, the axis of a spindle *f* passing through the centre of this triangle. The inner cylinder is rotated by the spindle, which is driven, through bevel gears and a magnetic clutch, from the shaft previously referred to. This rotation obviously brings the three tubes *e* successively into line with the street tube and two house tubes, airtightness of the tubes at the junction being ensured by the packing rings shown. It will be noted that a grid *g* is provided in the base plate at the bottom of the right-hand tube *e* in Fig. 44. Similar grids are provided in the cover, at the top of the other two tubes. A carrier entering the right-hand tube *e* by way of its unobstructed top, leaves one of the other tubes by the unobstructed bottom when the switch has been turned into the correct position. The converse holds good, a carrier entering the switch at the bottom leaves it at the top.

To follow the working of the rotary switch, Fig. 43 must now be referred to, but it is necessary to point out that this view, being diagrammatic only, does not show the three tubes of the rotary switch in their correct relative positions. It will be noticed in Fig. 43 that the two piston valves are so disposed in their casings as to couple the street tube, top left, to the vacuum header, bottom right. A carrier which has been inserted at a branch office in this particular street tube, is, then, drawn into the left-hand tube of the rotary switch in Fig. 43. As this tube corresponds to the right-hand tube *e* of Fig. 44, it will be evident that the carrier is stopped by the grid *g*, against which its buffer makes contact. It is essential for the carrier to signalise its entry into the switch without delay and this is effected by the differential indicator. As shown in Fig. 47, the indicator consists essentially of a rubber diaphragm reinforced by corrugated aluminium discs and situated in a closed chamber. A rod at the centre of the diaphragm actuates, through a spring-loaded lever, a pair of electrical contacts. The chambers at each side of the diaphragm are coupled by small pipes to the tubes above and below the rotary switch, as shown in Fig. 43. As long as no carrier is in the right-hand tube of Fig. 44, it will be clear that the load on both sides of the diaphragm is balanced and the contacts, in consequence, remain open, as shown in Fig. 47, the spring on the lever system correcting any pressure difference arising from the different positions of the pipe connections relative to the flow of the air.

Immediately a carrier is drawn into the switch and comes up against the grid *g*, a pressure difference sufficient to deflect the diaphragm and to close the contacts is set up. The completion of the circuit thus effected energises the magnetic clutch and couples the rotary switch to the continuously-rotating driving shaft. It will be obvious, however, that as soon as the switch begins to rotate, the conditions affecting the diaphragm of the differential indicator are altered and the contact is no longer held closed, but, as will be clear from Fig. 46, the circuit is provided with a retaining contact, which maintains it until the rotary switch has made one-third of a revolution. When this position is reached two things occur: The carrier is now in a position to be blown by low-pressure air into the house tube, that is, it is in the position indicated at the right-hand of rotary switch in Fig. 43. The second occurrence is that the motion of the rotary switch is arrested by the opening of the retaining contact. This opening is automatic and is effected by the cams on the base of the inner cylinder seen in Figs. 44 and 45. The rotary switch can receive another carrier as soon as one is ejected. It should be noted that the carrier must leave the switch at the opposite end to that at which it entered, as it must always travel buffer forwards. The carrier, on leaving the switch, travels along the house tube to the point of discharge at the pneumatic-tube table.

Reference to Fig. 52 will make it clear that the street tube is connected to the top of the central rotary switch since it would be impossible for a carrier to get round the sharp bends of the pipe coupled to the bottom of the switch at the left and leading upwards. This pipe, as a matter of fact, is that connected to the vacuum header. The particular switch here illustrated is used for receiving only and not for dispatching. The apparatus seen on the top, and which the street tube joins, is an emergency chamber. It consists simply of a casing with a hinged door having a window in the centre; the casing is surmounted by a sluice valve. Should two carriers arrive simultaneously the switch would be blocked and in case of this mishap the sluice valve is shut so that the door can be opened and there is no necessity to destroy the vacuum in the street tube. The door is locked by a hinged yoke and screw. This fitting is not required when the switch is used for both sending and receiving, as in this type of switch the air flow is reversible. The two pipes seen on the top of the switch to the right of the emergency chamber in Fig. 52 are low-pressure supplies for propelling the carriers into either of the two house tubes taken in an easy curve from the bottom of the switch. They are carried under the panel platform and then curve upwards again as seen to the right of Fig. 41. The minimum radius of the house tubes is 3 ft., that of the street tubes in the parts actually under the streets being 8 ft. 6 in.

So far, the reception only of a carrier from a branch office at the Central Telegraph Office has been described, viz., the "up" journey of a telegram form. As already stated, a number of the pneumatic tubes radiating from the Central Office serve for both "up" and "down" traffic. The arrangement shown in Fig. 43 is that adopted for such a two-way service. For the "down" traffic, *i.e.*, the dispatch of a message to a branch office, the carrier is inserted in the house tube at the pneumatic-tube table and enters the rotary switch by way of the middle tube seen below the switch in Fig. 43. It is drawn into the switch by a low vacuum and held with its buffer against a grid in the cover, the resulting pressure difference above and below the carrier actuating a second differential indicator. This causes rotation of the switch through an arc which brings the carrier into line with the street tube, buffer upwards. The carrier is dispatched along that tube by the high air pressure, the lower piston valves being traversed to the left, thus cutting off the connection with the vacuum header and opening that with the pressure header. The function of the upper piston valves, Fig. 43, is to break either the pressure or vacuum in the street tube. When moved from right to left, the right-hand piston closes the supply pipe and the left-hand one makes a connection between the street tube and the atmosphere. The two piston valves are constructed as shown in Fig. 42, control being by the Westinghouse electro-pneumatic valve seen to the left, which valve admits air at a pressure of 10 lb. per square inch behind the left-hand piston, so causing traverse to the right. The helical spring behind the right-hand piston effects traverse to the left when the air-pressure is released.

Control of the electro-pneumatic valves is effected automatically by a signalling circuit which, though somewhat complex, repays attention from its ingenuity. Referring to Fig. 40, a cylindrical lamp is seen attached to each of the "down" or dispatching tubes. The two bands denote the division of the lamp into three colours, red at the top, white in the middle, and green at the bottom. Near the bellmouth of each tube is a push-button, the lamp and button constituting all the visible parts of the system at the pneumatic-tube table and being indicated at the left of the left-hand dotted line in the lay-out diagram, Fig. 54, page 535. At the right of the right-hand dotted line is indicated the visible apparatus at the branch office to which the pneumatic tube concerned runs. It consists of two press-buttons and two dolls-eye, *i.e.*, oscillating signals. The main portion of the system is housed in the switch room shown in Fig. 41, some of it appearing on the panel illustrated in Fig. 52. The relays and other apparatus employed are indicated in the centre portion of Fig. 54 between the two dotted lines. It may be mentioned that this lay-out is for a short tube with both-way working, the adjective "short" implying that only one carrier travels at a time between the terminals. The signalling lay-out for a one-way tube is simpler, but that for a long both-way tube is more complicated as a number of carriers, spaced at definite intervals, are usually in the tube at the same time. It will be evident from the fact that there are push-buttons at both

TELEGRAM-FORM CONVEYING SYSTEMS; G.P.O.

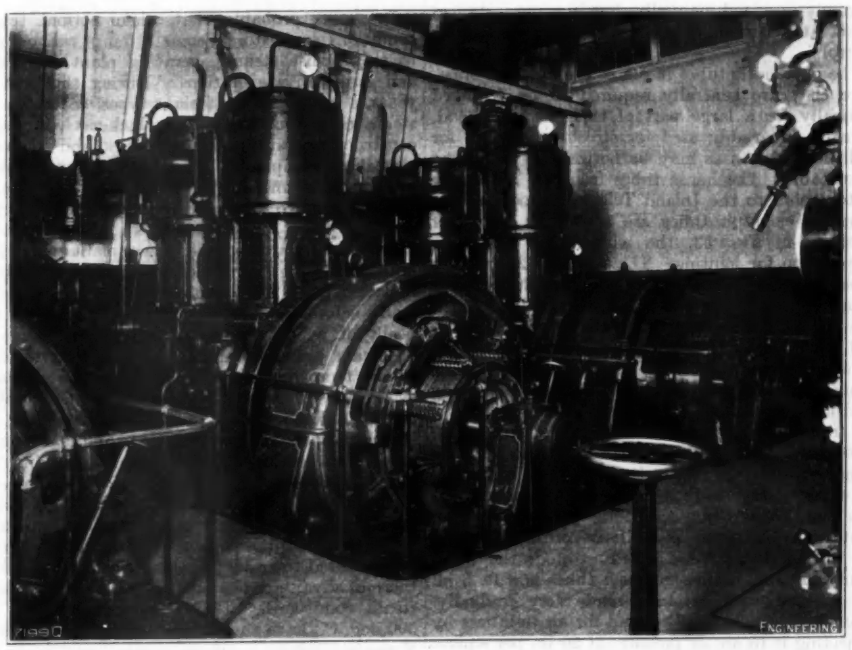


FIG. 55. MAIN AIR COMPRESSOR FOR STREET PNEUMATIC TUBES.

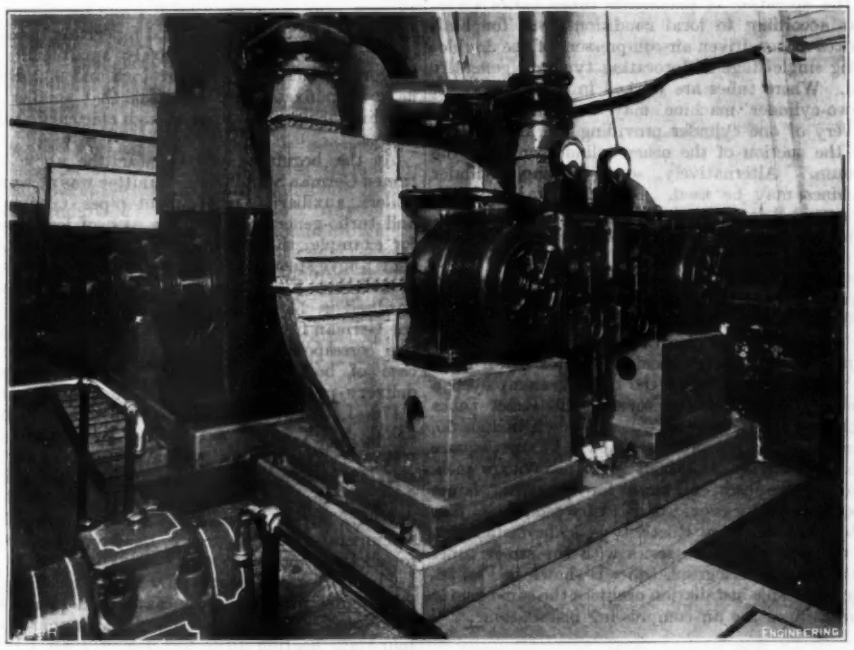


FIG. 56. HOUSE-TUBE CENTRIFUGAL FANS.

the Central Office and the branch offices that the air supply is controllable from either of them, the Central Office having control of the pressure for the outgoing or "down" carriers and the branch office controlling the vacuum for the incoming or "up" carriers. Each office can also reserve the tube for the next journey while a carrier is on its way in the other direction.

While a tube is in service one or other of the three lamps belonging to it on the pneumatic-tube table of the Central Office continues to glow. A red light indicates that pressure is on the tube; a white light that vacuum is on; and a green light that the tube is clear. Depression of the appropriate button while a white light is showing causes the tube to be reserved for the next journey, and, when the button is operated while the green signal is being shown it causes pressure to be put on the tube and the red light to be shown. The three signals are received at the branch office, as follows: When both doll's-eye indicators are down, the vacuum is known to be on; when that labelled "Reserve" is down, pressure is on; and when that labelled "Send" is down, the tube is clear. Operation of one of the push-buttons while the "Reserve" indicator is down causes the tube to be reserved for the branch office for the next journey, and if it is operated while the "Send" indicator is down vacuum is put on the tube. The other push-button, labelled "Receive," when operated, signals to the Central Office the receipt of a carrier from that office by changing the red light at the sending end to a white one. The tube is put under vacuum at the same time, so that the branch office is in a position to dispatch a carrier. This office may, however, wish to make certain that pressure will not be restored immediately that carrier is received at the Central Office, so preventing another carrier being sent by it. The branch office may, therefore, reserve the tube while a carrier is travelling from the Central Office by depression of the "Send" or "Reserve" button. In this case, although depression of the "Receive" button on receipt of the carrier cuts off the pressure at once, the vacuum is not put on and neither is the red signal changed until the "Send" or "Reserve" button has been depressed a second time. The converse of this occurs in the opposite direction.

The various parts of the mechanism outlined in the central portion of Fig. 54 are not, of course, shown in their actual relative positions; neither is all the wiring inserted, though all points which are connected are indicated by a long arrow-head. All relay-set tags are indicated by a small black disc with an attendant numeral. All contacts are shown in the unoperated position. There are two principal groups of relays. Those of the "down" group are distinguished by the letters P, P R, and P M, the first two being released by the central office "Send or Reserve" button, and re-operated by contact A 2 of a relay, which is released by the branch office "Receive" button. Relay P M operates when P releases, and is an auxiliary relay fitted with two mercury-tube contacts for controlling the "on-off" and "pressure-vacuum" electro-pneumatic valves, respectively, these valves actuating the double piston valves seen in Fig. 42. Three conditions are possible, viz.: (*a*) normal, in which P and P R are operated; (*b*) pressure on, in which P and P R are released; and (*c*) tube reserved by Central Office, in which P is held and P R released. The "up" group of relays is distinguished by the letters V, V R and V M, the first two being released by the branch office "Send" button or "Reserve" button and re-operated by contact C M 2 of relay C M, which is operated by the street-tube differential indicator. The relay V M operates as V releases, and is an auxiliary relay fitted with one mercury-tube contact for controlling the "on-off" electro-pneumatic valve. Three conditions are possible, viz.: (*a*) normal, in which V and V R are operated; (*b*) vacuum on, in which V and V R are released; and (*c*) tube reserved by branch office, in which V is held and V R released. The signal lamps are battery-operated.

The operation of the relays will be best understood by considering the sequence attendant on the depression of the push-buttons. When a carrier has been inserted in a house tube at the Central Office, the pressing of the appropriate button release P/5 and P R/2. The relay P 3 changes over the battery from the green lamp, indicating "Tube clear," to the red lamp, which is illuminated to show "Pressure on," P 2 at the same time changing over and operating P M/2, the two contacts of which actuate the "pressure-vacuum" valve so that pressure is put on the street tube. The relay P 5 changes over to remove the short-circuit from relay B, which then operates, B 1 changing over and the signal to the branch office being transferred from the "Send" to the "Reserve" doll's-eye indicator. At the same time, P 5 prepares the house-tube differential indicator circuit. The carrier at this point has reached the rotary switch and the differential indicator is operated in the manner already explained, C M/2 also being operated. The mercury contact C M 1 starts the rotary switch through the magnetic clutch, the rotation being continued through the necessary arc by the retaining contact. Passage of this contact by the cam on the rotary switch breaks the circuit and the switch stops in such a position that the carrier can be blown through the street tube, its arrival at the branch office being acknowledged by pressure of the "Receive" press-button.

This pressing movement releases A/2 and B/1, A 2 making contact and re-operating P/5 and P R/2, which are then held on P 1 and P R 1. The changing over of P 2 releases P M/2 and the air pressure is withdrawn from the street tube. At the branch office, B 1 transfers the signal from the "Reserve" to the "Send" indicator, while at the central office P 3 changes the signal from the red lamp to the green one. When P 5 changes over it re-operates A/2. During the time the carrier is in transit the change over of P 4 prevents the release of V/4 should the branch office inadvertently use

the "Reserve" button, this being necessary to stop V 2 operating V M/1 and so changing the air power from pressure to vacuum. At the same time, P 4 permits V R/3 to be released should the Central Office require to use the reservation facility. The above description of the functioning of the signal circuit refers only to the dispatching of a "down" carrier without reservation having been made. It is given as an illustration of the general operation, and it is not considered necessary to detail the sequence when the Central Office sends a "down" carrier and reserves the tube, or when the branch office sends an "up" carrier with or without reservation. Some account may, however, be given here of what is involved in a long both-way tube. The general operation of such a circuit is similar to that for short both-way tubes, except that two additional relays and a uniselector stepped by an earthed time pulse are needed and make the circuit somewhat more complex.

The group of controls shown in Fig. 52 is for a long both-way tube, the quadrantal uniselector being clearly visible. The long both-way tube is generally required to carry heavy traffic in one direction, with less in the other, and it would slow down transmission too much if the same procedure of sending one carrier at a time were adopted, as in the short both-way tube. A number of carriers are, therefore, dispatched at intervals and there may, therefore, be a number of them in the street tube at the same time. What are required then, are means for signalling what is known as the "minimum feeding interval" and for indicating the arrival of the last carrier of a train. The minimum feeding interval is necessary as, obviously, unrestricted feeding at the pneumatic-tube table would result in the blocking of the rotary switch. Both the signalling functions first referred to are fulfilled by the two additional relays and the uniselector, this latter being controlled by six-second impulses from an electric clock. In the case of a very long tube, 30-second impulses are provided. Briefly, the system functions as follows: Assuming the green signal, "Tube clear," to be shown at the Central Office, a carrier is inserted after the appropriate button has been pressed once. The signal then changes to red, "Pressure on," and the uniselector returns to the starting position, if it is not already there. From that position it turns at the rate of one step every six seconds until it reaches the contact selected as the "minimum feeding interval," when relays are operated which restore the green signal, thus permitting another carrier to be inserted. Although the "Receive" button is pressed at the branch office on the arrival of each carrier, it is rendered ineffective until just before the last of the train reaches that office. Should the traffic be heavy in both directions, it may be better to send one carrier each way at a time. If this is to be done, the reservation facility is used at both ends and the circuit then operates in exactly the same way as does that of the short both-way tubes.

From what has already been said, it will be understood that the automatic system above described has been fitted, so far, only at the Central Telegraph Office and the branch offices connected to it by pneumatic tubes. In other offices in the provinces the switches are simpler, having only two tubular sections by hand, and the pressure or vacuum is also manually connected. The flap terminals are, however, much the same in both cases, though horizontal types are common, but the signalling system differs considerably. Block instruments, as used in railway signal cabins, are employed to signal when the air supply is to be changed over and to indicate the presence of a carrier in the tubes. It is hardly necessary to illustrate the switches and other gear used in these systems, but the typical example illustrated in Figs. 48 to 50, Plate XXIX, is of interest as showing the general type of fitting. The apparatus shown is a diverting switch and is used so that a tube can be altered to deliver to either of two terminals. It may be, for example, that one of these terminals is used throughout the day and the other during the night, the latter terminal being in a different position from the former, owing to the smaller night staff. Again, an alternative route to avoid congestion may be required. The switch consists of a curved section of tube mounted between two end-plates, which can be rotated between fixed plates carrying the extension of the tubes to the terminals concerned. This switch is normally operated manually, but in some instances is actuated by an electric motor having remote control.

The pneumatic tubes in offices are made of brass, since they are generally required to be arranged vertically for a large part of their length; lead, which is invariably used for street tubes, and for such house tubes as may be horizontal, would not be suitable. The house tubes from the automatic switch room to the Inland Telegram Room of the Central Telegraph Office are shown, in course of erection, in Fig. 53, the white ends indicating preparation for jointing. The standard $2\frac{1}{4}$ in. bore brass tube is 0·048 in. thick, the lead tube of the same bore being $\frac{1}{8}$ in. thick. The lead is alloyed with 0·5 per cent. of tin and 0·5 per cent. of antimony, and each length of tube is finished internally by drawing a tightly-fitting steel mandrel, of the correct diameter and 12 in. long, through it, soft soap being used as a lubricant. The finished tubes are boxed for transport and when buried in the streets are protected by being laid in cast-iron pipes of suitable diameter. The lengths of lead tube are connected by wiped joints made over a heated mandrel. A slide on the cast-iron sheathing pipes covers the joint. The cast-iron pipes have ordinary spigot and socket joints. As already stated, the minimum radius allowable on street tubes is 8 ft. 6 in. and all changes in level are made very gradually. A finished tube is finally tested for air-tightness by subjecting it to an air pressure of 20 lb. per square inch for 24 hours.

The method of providing air pressure and vacuum for the operation of pneumatic tubes varies somewhat according to local conditions, but for both services motor-driven air-compressors of the double-acting single-stage reciprocating type are generally used. Where tubes are worked in both directions, a two-cylinder machine may be employed, the delivery of one cylinder providing the air pressure and the suction of the other cylinder creating the vacuum. Alternatively, separate single-cylinder machines may be used. Duplicate stand-by sets are provided in all important offices to avoid delay from breakdown. In smaller offices where only one set of compressors is installed, the delay caused by a breakdown is readily obviated by a messenger service between the two points. As, however, the air-compressing sets do not, in general, present any exceptional engineering problems, it is not proposed to deal with them in greater detail here, but as an illustration of the machines employed a view of the installation serving the street tubes at the Central Telegraph Office is given in Fig. 55, page 537. The low pressures, about $\frac{3}{4}$ lb. per square inch, and low vacua, about $\frac{1}{2}$ lb. per square inch, below atmosphere, required for operating house tubes are usually provided either by centrifugal fans or by blowers of the Root's type. The installation for the house tubes in series with the street tubes at the Central Telegraph Office is shown in Fig. 56, page 537. This installation occupies the same engine room as does the air-compressing installation.

MAN-COOLING FANS.—With the object of ameliorating working conditions in spaces where there is excessive radiated heat, as in front of steel furnaces, gas retorts, glass-melting pots, and the like, Messrs. Keith Blackman, Limited, Mill Mead-road, London, N.17, have developed a self-contained portable fan. As its name, "man-cooling" implies, the unit directs a stream of cool air into the spaces concerned so that the operators can work in comfort. The stream of air is not so concentrated as to cause an unpleasant draught, since the velocity is only about 100 ft. per minute at the extreme end of the stream, *i.e.*, at about 60 ft. from the unit, though the initial velocity is about 2,000 ft. per minute. The units are made with fans 12 in., 15 in. and 18 in. in diameter, mounted on a circular base. The whole unit can be placed so as to give the required horizontal direction to the stream, while the fan itself is swivelled for the vertical direction. The heavier units, viz., those from 24 in. to 42 in. in diameter, have gimbal-mountings to the fan so that any direction can be obtained without moving the whole unit, which can, however, be fitted with castors, if desired. The units are generally of fabricated steel and the current supply is by means of a trailing cable.

POWER-PLANT STANDARDISATION.

By C. H. S. TUPHOLME.

IT seems probable that, when normal trading conditions are restored, some attempt will be made to standardise steam-generating plant for central and large private stations. During the past ten years, a wide variety of plant types, capacities and steam conditions has arisen, which has led to heavy construction costs, slower deliveries, and the use of specialised equipment. Thus, in one country alone, of 65 boilers and 21 turbines installed in central stations, no two were alike except those working in the same plant. The advantages of at least a certain degree of standardisation of power plant are obvious, both in design, construction and the supply of replacements. A beginning in this direction was made before the war by the German V.D.I., as a result of which recommendations were made for 15 steam pressures and a corresponding series of steam temperatures. For electric power plants, steam pressures have been fixed in Germany at 569, 910, 1,138 and 1,778 lb. per square inch, and steam temperatures at 842 deg. and 932 deg. F. At the time, steam at 1,778 lb. per square inch and 932 deg. F. was considered by German engineers to be the highest practicable limit. In Continental practice the use of this pressure and temperature involves reheating, and many German engineers have refused to employ such a pressure because the thermal advantage is a moot point. The next lower steam conditions, 1,138 lb. per square inch and 500 deg. C., have thus been fixed by the Deutscher Normenausschuss as those at which the maximum permissible moisture in the steam in the last turbine stage can be realised without preheating, *i.e.*, about 12 per cent. In peak-load stand-by plants for hydro-electric installations, and for certain industrial conditions where comparatively small units are concerned, 569 lb. per square inch and 932 deg. F. have been fixed, for the reason that smaller condensing turbines will work at high efficiency at these figures.

At the beginning of the war the above-mentioned German Standards Committee was at work on boilers, auxiliaries, power-plant pipes, economisers and turbo-generators. In the case of feed pumps, for example, the pressure recommended was 15 per cent. above steam pressure, and a water temperature of 302 deg. F. Pump capacities have been standardised in 14 sizes, and, to cope with overloads, the German Committee recommend the next larger size corresponding with the boiler rating. In the case of boilers with natural circulation, pump-delivery pressures for the four steam pressures of 1,178, 1,138, 910 and 569 lb. per square inch are 2,050, 1,310, 1,050 and 655 lb. per square inch, respectively. Feed-water temperatures for the four standardised steam pressures, using pulverised-coal firing, have been fixed at 392, 374, 347 and 302 deg. F., respectively. For stoker or grate firing, a temperature of 302 deg. F. has been standardised for all steam pressures.

For feed-water heating by stage bleeding, the final temperatures and the extraction points have been fixed. These are, for 1,778 lb. per square inch, four-stage heating up to 392 deg. F.; for 1,138 lb. and 910 lb. per square inch, four-stage heating up to 374 deg. F.; and for 569 lb. per square inch, three-stage heating up to 302 deg. F., assuming pulverised-coal firing in all four cases. For stoker or grate firing, three-stage heating up to 302 deg. F. is specified for all pressures.

According to articles published in the technical Press of the United States, work is now going on in Germany in connection with the standardisation of turbo-generators. Here the committee is finding difficulties, in the basic differences in types and limitations, in establishing types for each manufacturer separately. Six load groups for condensing turbines between 500 kW and 50,000 kW, and four between 5,000 kW and 20,000 kW, for superimposed installations, have been recommended. In the United States, the standards determined by the National Defence Power Committee about a year ago, provide for nine load groups for condensing turbines between 10,000 kW and 100,000 kW, and seven for superimposed turbines between 10,000 kW and 60,000 kW. For extraction and back-pressure

turbines, as employed in industrial plant service standardisation has proved particularly difficult because of the great variety of applications, and so far no definite recommendations have been made although the problem is being studied.

Power-plant pipes are also being standardised in Germany. For high pressures and temperatures alloy steel has been specified, and, in the manufacture of such pipes in the electric furnace, minimum charges are fixed and rolled lengths determined. Any surplus short lengths obtained by cutting standard lengths during erection must be used as opportunity occurs, in situations where ordinary steel would do, so that waste is avoided. Materials, sizes and wall thicknesses have been standardised for the four steam pressures, 1,778, 1,138, 910 and 569 lb. per square inch for 38 different pipes. For 1,778, 1,138, and 910 lb. per square inch and 932 deg. F., the pipe must be of chromium-molybdenum steel, with a cold tensile strength of 64,000 lb. to 78,000 lb. per square inch and a permanent strength of 23,000 lb. per square inch at 932 deg. F. For the fourth pressure, of 569 lb. per square inch and 842 deg. F., the German Committee specifies a copper-molybdenum steel with a cold tensile strength of 54,000 lb. to 64,000 lb. per square inch and a permanent strength of 17,000 lb. per square inch at 842 deg. F.

SHORT-CIRCUITS ON TRANSMISSION LINES.

Fig. 41.

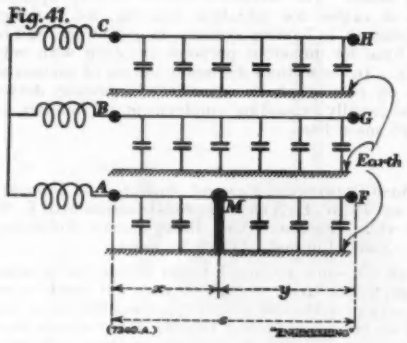


Fig. 42.

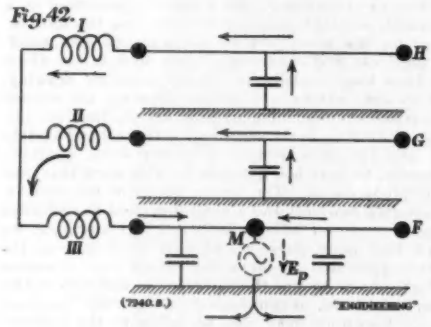


Fig. 43.

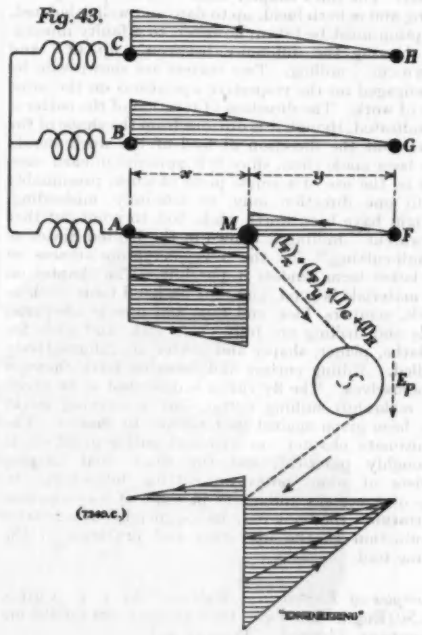
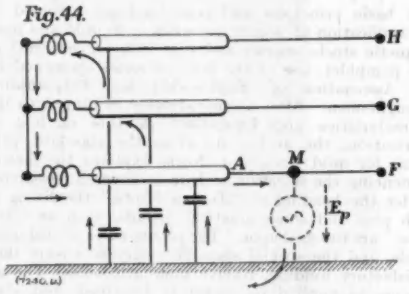


Fig. 44.



SOME EFFECTS OF SHORT-CIRCUITS ON THREE-PHASE TRANSMISSION LINES.

By T. F. WALL, D.Sc.

(*Continued from page* 479.)

PART II.

11. *One Line of a Three-Phase Transmission System with Insulated Star Point is Short-Circuited to Earth.*—In Fig. 41 is shown a three-phase transmission system of total length s cm., the line being shown open at the receiver's end. If this system is fully insulated, the earth current will be,

$$I = E_p \omega c s \text{ amperes},$$

where E_p is the phase pressure and c farad per centimetre length is the distributed capacitance of the line to earth. Now suppose that one line becomes earthed at some point M distant y cm. from the generator and x cm. from the receiver's end, so that the total length of the line is $s = x + y$ cm. The determination of the additional earth current which will flow due to this short-circuit can easily be found by means of the phantom e.m.f. method, as already explained in Part I, section 8, page 406, *ante*.

Thus, the additional earth currents due to the short circuit at M (Figs. 42 and 43), in the respective lines F, G, and H, will be

$$I_x = E_p \omega c x;\ I_y = E_p \omega c y;\ I_G = E_p \omega c s;$$
$$I_H = E_p \omega c s,$$

so that the total extra earth current due to the short-circuit at M will be

$$3 E_p \omega c s \text{ amperes},$$

which is three times the normal earth current per phase in the fully insulated line.

This additional earth current will be a single-phase current and will be distributed among the three lines of the system. The actual earth currents which will then flow will be obtained by superposing the current in each line, as shown in Fig. 43, on the normal earth current when the whole system is fully insulated. It will then be found, for example, that the resultant earth current in the portion M F of the defective line will be zero, as, of course, must be the case, since the potential to earth of this part of the line is zero. Hence, whereas in the normally-insulated system the earth currents form a symmetrical three-phase current system, the short-circuit of one line to earth gives rise to a highly unsymmetrical capacitance current which the generator is called upon to supply.

As already pointed out, the additional earth current due to the short circuit of one line to earth will be a single-phase current and, since the lines have distributed inductance as well as distributed capacitance, the possibility of resonance phenomena being developed has to be considered. If the inductance of the line is l henry per centimetre length and the capacitance is c farad per centimetre length, these quantities will be related as follows, viz.,

$$\frac{1}{\sqrt{l \cdot c}} = u = 3 \times 10^{10} \text{ cm. per second},$$

that is, the velocity of light in open space. (See also Part I, section 4.)

Now it can be shown that when a line is on open circuit, standing waves of current pressure of wavelength λ will be developed, so that,

$$\lambda = \frac{u}{f} = \frac{1}{f\sqrt{l \cdot c}},$$

where f is the frequency of the supply pressure.

When the length of the line $\frac{1}{4}\lambda$ is one-quarter of a wavelength, dangerously high pressure rises due to resonance will be developed, that is, when

$$s \mathrel{\widehat{=}} \tfrac{1}{4}\lambda \mathrel{\widehat{=}} \tfrac{1}{4}\frac{u}{f}$$

or, otherwise stated, when the supply frequency is

$$f \mathrel{\widehat{=}} \frac{u}{4s} \mathrel{\widehat{=}} \frac{1}{4s\sqrt{l \cdot c}} \text{ cycles per second.}$$

For overhead lines operated at 50 cycles,

$$s = \frac{u}{4 \times 50} = \frac{3 \times 10^8}{200} = 1{,}500 \text{ km.}$$

For underground cables,

$$s = \frac{1{\cdot}5 \times 10^8}{200} = 750 \text{ km.}$$

Such long lines will not usually be met with in practice. If, however, the wave-form of the supply e.m.f. comprises a pronounced harmonic, say, the fifth, then the line will be in resonance with that harmonic when, for an overhead line,

$$s = \frac{u}{4 \times 5 \times 50} = 300 \text{ km.}$$

and for an underground cable when

$$s = 150 \text{ km.}$$

and such lengths as these may easily be found in practice.

There is, however, one other important practical case of resonance which might easily occur if precautions were not taken to avoid it. This case is illustrated in Fig. 44, in which a system is shown comprising an underground cable in series with an overhead line. In this case it may be assumed as a practical approximation that the capacitance of the overhead line and the inductance of the underground cable are relatively small. The inductance of the overhead line may be treated as forming a simple series circuit with the capacitance of the underground cable and these constants may be such that marked resonance phenomena may be obtained.

Example.—The cable system shown in Fig. 44 is 250 km. long and the line pressure is 10,000 volts, that is, 5,800 volts phase pressure, and the capacitance to earth of all three cables in parallel is 100 μ F. A short-circuit to earth occurs on one line at the point M, which is 30 km. from the end A of the cable, the inductance of the length of overhead line A M may be taken to be 60 milli-henry (see also Part I, section 4).

The resonance frequency for the series arrangement of 60 milli-henry and 100 μ F will be

$$\frac{1}{2\pi}\sqrt{\frac{1}{60 \times 10^{-3} \times 100 \times 10^{-6}}} = \frac{10^3}{2\pi\sqrt{6}} = 65.$$

Although this frequency is not exactly the same as that of the supply pressure, viz., 50, it is sufficiently close to it to produce dangerous pressure rises. The value of such pressure rises may be found by means of the formula already obtained in a previous article.*

Thus, neglecting resistance, if the resonant circular frequency of the series connection of capacitance and inductance is ν radians per second, then the impedance of the circuit for a supply circular frequency of ω radians per second will be given by the expression

$$Z = \frac{1}{\omega c}\sqrt{1 - \left(\frac{\omega}{\nu}\right)^2} \text{ ohms},$$

* ENGINEERING, vol. 139, page 110 (1935). Also R. Rüdenberg, *Elektrische Schaltvorgänge*.

so that the current will then be given by the expression,

$$I = \frac{E_p}{Z} = \frac{E_p\ \omega\ c}{\sqrt{1 - \left(\frac{\omega}{\nu}\right)^2}} \text{ amperes.}$$

In the present example, therefore, the current will be

$$I = \frac{E_p}{Z} = \frac{5{,}800 \times 314 \times 10^{-4}}{\sqrt{1 - \left(\frac{50}{65}\right)^2}} = \frac{182}{0{\cdot}63} = 288 \text{ amperes,}$$

and the p.d. across the cables will be

$$E_c = \frac{I}{\omega\ c} = \frac{E_p}{\sqrt{1 - \left(\frac{\omega}{\nu}\right)^2}} = \frac{5{,}800}{0{\cdot}63} = 9{,}300 \text{ volts.}$$

It is further to be observed that a transient current may be developed on sudden short circuit which may give rise to a peak value of the initial current something like twice the peak value of the current calculated in accordance with the foregoing formulæ and, consequently, produce a corresponding momentary excessive pressure across the cable. In such cases, the cable would almost certainly be destroyed (see also Part I, section 5).

In order to eliminate the possibility of these heavy currents and high pressure rises due to resonance or partial resonance, it is customary to avoid connecting an overhead line directly to an underground cable. The overhead lines and cables can then be coupled by transformers with a 1 : 1 ratio and in this way the circulation of the heavy resonance currents in the cables is prevented.

(To be continued.)

NOTES ON NEW BOOKS.

Metallurgical Analysis and Assaying. By J. STEWART REMINGTON and F. L. JAMESON. London: The Technical Press, Limited. [Price 5*s.* net.]

THIS book is intended primarily to assist those who, having had only a limited systematic training in analytical processes, find themselves faced with problems of metallurgical analysis. The need for such a book has long been evident and this volume should supply what is required. It contains a number of valuable features and some departures from the more traditional introductions to chemical analysis. The authors have made a judicious selection of standard methods and there is abundant evidence throughout of sound critical judgment. Considered as a technical book, it suffers inevitably from the fact that the subject is too vast to be treated briefly, but the majority of the metals and non-metals are discussed. The early chapters are devoted to a study of the determination of the metals of groups 1 to 4 in the analytical table, reference being made to the electrolytic assay of mercury and copper and the colorimetric determination of iron and manganese. The authors recommend the modification of Hutchin and Tonk's method, proposed by Wraight, as the best for the estimation of tungsten. Sulphur, in most ores with which the assayer has to deal, generally exists as the sulphide, but it is sometimes necessary to determine not only the total sulphur content, but also in which form it exists and in what proportion. A suitable procedure for either requirement is outlined. A rapid method for the estimation of sulphur in the absence of iron, zinc and lead is also given, together with some details of the technique of scorification and cupellation in the assay of silver and gold ores. The final section of the volume is devoted to a general scheme for the complete assay of a manganese ore. The authors are to be commended on a useful piece of work, which should facilitate the labours of assistants in metallurgical laboratories.

Cutting Tools for Engineers. By A. H. SANDY. London: Crosby Lockwood and Son, Limited. [Price 3*s.* 6*d.* net.]

THE author of this work, a lecturer in the Borough Polytechnic, London, naturally writes primarily for the engineering student and apprentice, but the standard set is by no means elementary, and its pages contain much which will be useful to a wider circle. The book does not describe in detail such machines as the lathe, planer, or milling machine, but only the cutting tool itself, whether that be a hand chisel or a diamond-tipped cutter held in a tool post. At the same time, the second chapter states briefly the principles of the leading types of machine tools. It is unfortunate that the term "spiral" is still used to describe a helix and is so employed when referring to a hob in that chapter. The third chapter deals with the principles of cutting and is both lucid, up to date and well tabulated. Exception must be taken, however, to a faulty illustration showing the difference between "up-cut" and "down-cut" milling. Two cutters are shown side by side engaged on the respective operations on the same piece of work. The direction of rotation of the cutter is not indicated, though it is obvious from the shape of the teeth; but the direction of feed of the work should have been made clear, since it is opposite in each case. As it is, the use of a single piece of work, presumably fed in one direction only, is definitely misleading. It might have been worth while, too, to point out that "down cut" milling is known in the United States as "climb-cutting," for the very inappropriateness of this latter term renders it puzzling. The chapter on tool materials is good, and that on hand tools, such as chisels, scrapers, files, and taps and dies is adequate. Drills and drilling are fully dealt with, and tools for the lathe, planer, shaper and slotter are informatively handled. Milling cutters and broaches have chapters to themselves. The fly cutter is described as an excellent makeshift milling cutter, but a warning might have been given against its tendency to chatter. The penultimate chapter, on tool and cutter grinding, is thoroughly practical, and the short final chapter consists of some notes on cutting lubricants. In spite of a certain ambiguity in some of its numerous illustrations, the book may be commended as a reliable introduction to the operation and problems of the cutting tool.

Principles of Electric Arc Welding. By I. H. CHILD, B.Sc.(Eng.). London: The Draughtsman Publishing Company, Limited. [Price 2*s.* net.]

THE basic principles and considerations involved in the application of electric-arc welding to mild and non-magnetic steels, copper and cast iron are outlined in this pamphlet, one of the familiar series sponsored by the Association of Engineering and Shipbuilding Draughtsmen. After an introduction dealing with the characteristics and limitations of this method of fabrication, the author describes the standard weld forms for mild steel, and clearly explains the factors influencing the selection of bare or covered electrodes. Under the heading of "Design Hints," the fixing of stub pins and some practical pitfalls, such as "arc-blow," are touched upon. The peculiarities of austenitic steels, and the special steps necessary to ensure their satisfactory welding, receive some attention. The arc process as applied to copper is described, and some practical data given for this work; and, finally, cast-iron welding is discussed, with special reference to repair work, in which it is most extensively used. The wide scope of this pamphlet is responsible, no doubt, for the fact that some points have received little more than a mention and do not stand out with the prominence due to their importance. Distortion, common to all types of fabrication, is referred to, but is not adequately stressed. "Arc-blow" is dismissed in a few words, and it is possible that those who have not observed this phenomenon may also dismiss it as being somewhat obscure and of little account. The importance of the human factor, involving the skill and reliability of the operator, is stressed more than once, with justification. A comfortable position for working cannot always be obtained, although it goes a long way towards ensuring a sound weld, but much can be done by providing the maximum accessibility. These and other practical points should commend this publication in many drawing offices, but it is doubtful whether the approval will extend to the illustrations, which are unexpectedly crude.

Rubber and Railways. By COLIN MACBETH, M.I.A.E. Second Edition. London: The British Rubber Publicity Association.

RAILWAY engineers in this country have been quick to appreciate the value of rubber in rolling-stock construction and are making increasing use of its special properties in developing new designs. Nevertheless, there is still scope for improvement in passenger amenities as well as in the elimination of vibration and shock from the structure and mechanism of vehicles. The British Rubber Publicity Association have, therefore, revised their handbook, originally published in 1931, to keep pace with new developments and especially with such as have been adopted by leading railway systems as standard practice. Drawings and information, supplied from official sources, set out in detail the ways in which railways of several countries use rubber in their designs. About one-third of the rubber is used for buffing and draw-gear, while nearly a quarter is applied as auxiliary springing to supplement the usual steel suspension springs of vehicles. A large part of the book is devoted to describing the manner of its application to these functions in typical vehicles. The use of rubber to secure constant, cushioned contacts within bogie bolster mountings is amply demonstrated, the originality of American technique in this practice being noted. The better-established railway applications of rubber for vibration damping, for packings and jointing, in lighting systems, in coachwork, and in hose form for numerous purposes are dealt with only briefly. In the sections discussing the use of pneumatic tyres on railway wheels, attention is specially drawn to the rapidly expanding employment of rail-cars on French main lines.

Freehand Drawing and Pictorial Illustration for Draughtsmen. By W. H. KERRY (in collaboration with E. W. STOTT). Epsom: The Draughtsman Publishing Company, Limited. [Price 2*s.* net.]

THERE are some technical books which the reviewer is tempted to treat, though he may not yield to the temptation, in the old style of "cutting the leaves and smelling the paper-knife," but Mr. Kerry's little book on drawing is definitely not one of them. Without padding or irrelevancy, the matter is presented in a pleasantly readable and direct form, and the illustrations, for the most part by the author's own hand, are pertinent and convincing. The book is one which has been long needed, for though isometric drawing, and to some extent, perspective drawing, are treated in certain text-books on machine design, they are not there coupled up in the same way with freehand sketching, and the draughtsmen of to-day seem, speaking generally, to have less aptitude for this work than had their predecessors. The advice given in the book is thoroughly practical and a careful perusal has afforded little grounds for adverse criticism. If anything, we think that more stress might have been laid on the pitfalls presented by over-elaboration; as a matter of fact, one or two of the illustrations suffer from this defect and have, in consequence, a "muddy" appearance. Exception may also be taken to the authors' method of the line shading of spherical surfaces, the usual convention of the high lights being those resulting from rays downwards at 45 deg. to the horizontal and also to the plane of the paper not having been observed. There are one or two other small points, but they do not really detract from the utility of the book, and that the author has a competent knowledge of his subject is shown by his commendation of an "exploded view" of an internal-combustion engine, which, taken from the columns of our contemporary, *The Motor Cycle*, is an example of this method of presentation that could hardly be bettered. In conclusion, it may be pointed out that the whole tenor of the book is not, as might be assumed from its title, to enable a draughtsman to become an artist, but to help him to convey a clearer understanding of a machine, apparatus or structure than could be obtained from formal plans, elevations and sections, particularly as those formal drawings often make a heavy demand on the time of the non-technical person and not infrequently also tax his intelligence.

Factory Costing and Organisation. By H. H. EMSLEY, B.Sc. (Eng.), and J. LOXHAM, A.M.I.Mech.E. 2nd edition. London: Constable and Company, Limited. [Price 9*s.*]

IN the study and practice of a subject so detailed as the cost of workshop production, it is well occasionally to view it from a distance; the perspective will be improved, and the different parts of the subject will more readily appear in their relative importance. It may be found that the relative values have to be modified as a result of the bird's-eye view. This book provides just such an opportunity, being based on a course of lectures given to engineering students, and presenting what may be fairly described as an external view of the subject. The book commences with the elements of cost, that is, of material, labour, on-cost, distributing cost and profit, making up the selling price; then the subject is developed step by step to cover the whole engineering works organisation. The authors endeavour, however, to cover too large a field, and do rather less than justice to some of its individual parts. For example, the chapters on "Cost of Materials" and "Departmental Division of On-cost," could have been elaborated with profit. The discussion of "Cost of Labour" in Chapters III and IV, however, is well worth detailed study, and summarises most of the useful systems and aspects of this difficult problem. All these systems, of course, share the common principle of offering an inducement to the worker to increase his output, so that the total overhead expenses of the factory for a given period will be spread over an increased number of articles, but the means whereby this aim is achieved present, in their variety, an informative study when directly compared. Apart from the shortcoming mentioned, however, this may be commended as a helpful book, embodying much practical experience.

"GEOMETRIC" JIG-BORING MACHINE.

MESSRS. MEYER MECHANICAL LABORATORY, SAN FRANCISCO, U.S.A.

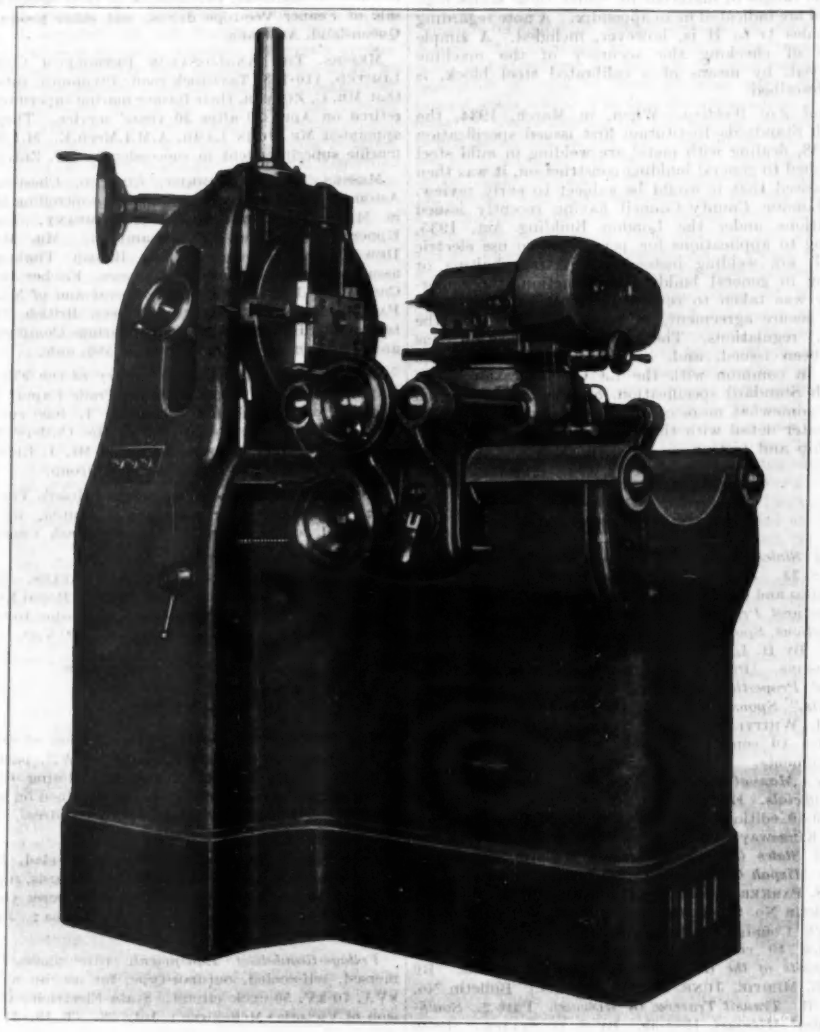


FIG. 1. MACHINE AS SET FOR BORING PARALLEL HOLES.

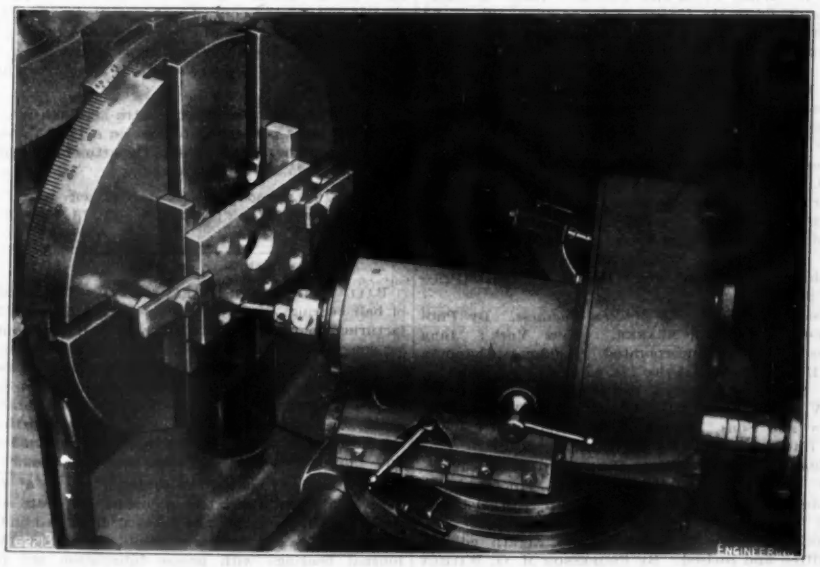


FIG. 2. SETTING OF SPINDLE HEAD FOR ANGLED HOLES.

LINCOLN ELECTRODE FOR INCONEL ALLOY.—Messrs. Lincoln Electric Company, Limited, Welwyn Garden City, Herts, inform us that their electrode for welding the nickel-chromium-iron alloy Inconel, hitherto termed "Inconweld," will, in future, be known as "Nickel-chromeweld." This is a shielded-arc electrode and it is also suitable for welding other corrosion- and heat-resisting alloys similar to Inconel.

"GEOMETRIC" JIG-BORING MACHINE.

THE machine shown in the accompanying illustrations, Figs. 1 and 2, known as the "Geometric" jig borer, has been developed by Messrs. Meyer Mechanical Laboratory, 1849, Sacramento-street, San Francisco, U.S.A., and possesses a number of novel and interesting features. In the first place, it will be noted that the work is carried on a vertical faceplate, which not only contributes to visibility of the operation, but ensures natural clearance, by gravity, of the swarf; and, by the employment of a surface plate supported on the ways of the bed, enables checking to be done before the work is removed from the machine. Secondly, the spindle is driven by an individual motor and the head is moved inwards as a whole to give the necessary feed to the tool. This construction eliminates the use of a sliding quill to the spindle and as the tool chuck is always in the same position relative to the head the overhang is invariable and is of minimum amount. The employment of an independent ½-h.p. motor, which drives the spindle through Vee-belts, renders toothed gearing with its attendant wear, unnecessary. The spindle speed range is variable, in 10 steps in geometrical progression, from 294 r.p.m. to 2,350 r.p.m., and the direction of rotation is reversible. In the third place, the faceplate, which is locked in place when small parallel holes are being bored, is rotated for larger parallel holes up to 3 in. in diameter, and for taper holes, the work being thus driven as in a lathe. The speed range of the faceplate is from 30 r.p.m. to 437 r.p.m. in four steps in geometrical progression. It is driven, through Vee-belts by a motor of ½ h.p., one direction of rotation only being available. The spindle head is adjustable on a vertical axis to provide the requisite inclination for boring taper holes.

Some of the leading characteristics of the machine having been outlined, its construction may now be considered. In the general view, Fig. 1, it will be observed that the ways on which the saddle is carried, and also those on which the spindle head is cross-traversed, are not the conventional surfaces machined on the bed and saddle, but are independent circular shafts. These are of steel, hardened, ground and lapped, the bearing surfaces for both sets in the saddle consisting of similarly finished steel bushes, automatically oiled. The maximum bearing pressure at any point on the way surfaces is less than 10 lb. per square inch, and the surfaces themselves have a Rockwell C scale hardness of between 62 and 63. The holes in the bed and saddle for taking the ways are bored from fixtures to secure accurate alignment. The base of the machine is a single heavily-ribbed and rigid casting, normalised to free it from internal stress, and having a three-point bearing on the foundation. The faceplate unit has vertical travel on circular ways of the same type as the horizontal ways and carried in a columnar extension of the base; it has an adjustment of 10 in. The spindle head has a cross traverse of 16 in., so that the capacity of the machine is such that any hole within a rectangle of 10 in. by 16 in. can be bored, these dimensions being, of course, the centre lines of the extreme rows of holes.

The enlarged view, Fig. 2, shows the machine set up for angular boring, which is done by setting the spindle head at the appropriate angle, as shown. The faceplate is fixed and the tool rotates. For taper boring the spindle head is also angled in the horizontal plane and the hole to be tapered is set on the axis of the faceplate, which is rotated, while the spindle is locked. The action in this case somewhat resembles that of a lathe. Reamers and milling tools can be used as well as drills and boring tools. It will be noticed that the periphery of both the face-plate and the spindle head are both graduated for setting purposes, the former having a Vernier reading to 5 minutes, the periphery being graduated in degrees for the full circle. The spindle head is graduated in the same way but has a setting pointer only. Measuring is done directly from the drawing by means of built-in mechanical counters and precision screws with 6-in. micrometer dials and Verniers. The screws are of tool steel and have Acme threads. They are first machined, then hardened to 53 to 56 Rockwell C scale, ground all over, seasoned, finish-ground all over and finally lapped. The lead accuracy is such that the maximum error is 0·0001 in. per inch of length. The maximum error between any two points on the cross-traverse screw is 0·00025 in., and that on the face-plate screw is 0·0002 in. Spacing on the full capacity can, therefore, be done accurately to 0·00025 in., and when the holes lie within a smaller area, to 0·0001 in.

At the commencement of a job the vertical and cross traverse counters and micrometer dials are set at zero, this operation setting up two base-lines from which all measurements are made. The screws are then turned by their handwheels, while the operator watches the appropriate counter until it indicates the desired amount, which it does to one-hundredth of an inch. The micrometer dial, reading in thousandths

of an inch, and the Vernier, reading in ten-thousandths of an inch, are then used to set the machine to its finest degree of accuracy. The mechanical counters prevent error in reading the turns given to the hand-wheel. The precision screws operate in long close-fitting bronze nuts and, since the cross traverse and faceplate are locked by self-equalising clamps while boring, the stress and wear on these screws is negligible. As already stated, the feed to the tool is given by movement of the saddle. When power is used, a $\frac{1}{10}$-h.p. motor being provided for this purpose, five rates of feed, ranging from $\frac{1}{4}$ in. to 3 in. per minute, are available. With hand feed, the rate is 1 in. per turn of the hand-wheel and the full longitudinal traverse is 18 in. Hand-wheels are provided for both the rotary and vertical adjustment of the faceplate. Hand rotation of the faceplate is used for such purposes as milling an arc, and for inspection, as well as for setting. The surface table is not shown in either illustration, but is normally used resting on the table ways, the saddle being run back out of the way.

As regards other details of construction, both the faceplate and rotatable-spindle head are mounted on double-row cylindrical roller bearings. The motors are dynamically balanced and are normally supplied for three-phase alternating current at 220 volts and 60 cycles, though other conditions can be arranged for. Higher speed ranges, up to a spindle speed of 7,000 r.p.m., cutting lubricant pump, and different accessories, such as a collet attachment for the faceplate spindle, can be provided if required. The British agents for Messrs. Meyer Mechanical Laboratories are Messrs. E. H. Jones (Machine Tools), Limited, Edgware-road, The Hyde, London, N.W 9.

BRITISH STANDARD SPECIFICATIONS.

THE following specifications of engineering interest have been issued by the British Standards Institution. Copies are obtainable from the Publications Department of the Institution, 28, Victoria-street, London, S.W.1, and, unless otherwise stated, the price is 2*s.* net, or 2*s.* 2*d.* including postage.

Building Limes.—A standard specification for cement was among the earliest publications issued by the British Standards Institution, but, although lime is an older building material, it has only recently been possible to issue a standard specification dealing with it. The preparation of this standard was commenced by the Institution some years ago, but many difficulties and problems arose which could only be solved by research extending over a considerable period of time. The most difficult question was that of devising a suitable method for the determination of the hydraulic strength of hydrated lime. In a specification for building limes (No. 890-1940), which has now been issued, a method of test for the determination of hydraulic strength has been included, but a note is added pointing out that the test is to be regarded as tentative only. Its suitability as a standard test is to be reviewed when experience of its use has been obtained by the industry. The specification deals with quicklimes and with hydrated limes, each of which may be either of the non-hydraulic or of the semi-hydraulic type. Both the quicklimes and the hydrated limes are divided into two classes, namely, Class A: material for plastering finishing coat, coarse stuff, and building mortar; and Class B: material for coarse stuff and building mortar only. For each type of lime the chemical composition, residue on slaking (or, in the case of hydrated limes, fineness), volume yield (for quicklimes), workability, soundness, and hydraulic strength (for limes of the semi-hydraulic type) are laid down. The procedure to be adopted in slaking quicklimes is set out in an appendix, and further appendices contain methods of carrying out the various tests specified. [Price 3*s.* 6*d.* net, or 3*s.* 8*d.* post paid.]

Front Lamps for Tramway Cars.—With the object of assisting passenger road-transport operators to comply with the Lighting (Restrictions) Order, 1940, in regard to the masking of the front lamps of tramway cars, the British Standards Institution has issued a specification (B.S./A.R.P. No. 41) dealing with this matter. The first portion of the specification defines the conditions governing the utilisation of the lamps, and this is followed by a description of a design for a masking device which fulfils the conditions laid down. [Price 3*d.* post paid.]

Direct-Reading Rockwell Hardness Test.—In response to representations received from engineers engaged in many spheres of activity, the British Standards Institution has issued a further specification in its series dealing with hardness testing. The new publication, which is designated No. 891-1940, concerns direct-reading hardness testing on the Rockwell principle. In addition to standardising the manner in which the Rockwell test is made, it has been necessary to include in the publication requirements relating to the machine itself, as the accuracy of the test is largely dependent on the accuracy of the machine. The specification covers the three scales A, B, and C only, and the ranges of materials for which these scales may be used are indicated in an appendix. A note regarding the scales D to H is, however, included. A simple means of checking the accuracy of the machine employed, by means of a calibrated steel block, is also described.

Metal Arc Welding.—When, in March, 1934, the British Standards Institution first issued specification No. 538, dealing with metal arc welding in mild steel as applied to general building construction, it was then emphasised that it would be subject to early review. The London County Council having recently issued regulations under the London Building Act, 1935, relating to applications for permission to use electric (metal) arc welding instead of riveting, bolting or lapping in general building construction, the opportunity was taken to review specification No. 538 so as to secure agreement, as far as possible, with the L.C.C. regulations. The revised specification has now been issued, and, as might be expected, has much in common with the L.C.C. publication. The British Standard specification, however, is considered to be somewhat more comprehensive, in that it deals in greater detail with the important aspects of workmanship and testing.

BOOKS RECEIVED.

United States National Bureau of Standards. Report BMS 33. *Plastic Calking Materials.* By J. J. TREGONING and others. [Price 10 cents.] Report BMS 38. *Structural Properties of Two "Dunstone" Wall Constructions, Sponsored by the W. E. Dunn Manufacturing Co.* By H. L. WHITTEMORE, A. H. STANG and D. E. PARSONS. [Price 10 cents.] Report BMS 39. *Structural Properties of a Wall Construction of "Pfeifer Units," Sponsored by the Wisconsin Units Co.* By H. L. WHITTEMORE, A. H. STANG and D. E. PARSONS. [Price 10 cents.] Washington: Superintendent of Documents.

Garcke's Manual of Electrical Undertakings and Directory of Officials. Editor: F. C. GARRETT. Volume XLII. 1939-40 edition. London: Electrical Press Limited, 60, Kingsway, W.C.2. [Price 37*s.* 6*d.* net.]

United States Geological Survey. Bulletin No. 906-C. *The Mizpah Coal Field, Custer County, Montana.* By F. S. PARKER and D. A. ANDREWS. [Price 1·50 dols.] Bulletin No. 906-D. *Geology of the Searchlight District, Clark County, Nevada.* By EUGENE CALLAGHAN. [Price 40 cents.] Bulletin No. 910-B. *Platinum Deposits of the Goodnews Bay District, Alaska.* By J. B. MERTIE, JUNR. [Price 15 cents.] Bulletin No. 916-B. *Transit Traverse in Missouri.* Part 2. *South-Central Missouri*, 1908-39. By J. G. STAACK. [Price 25 cents.] Washington: Superintendent of Documents.

United States Geological Survey. Water-Supply Paper No. 845. *Water Levels and Artesian Pressure in Observation Wells in the United States in* 1938. Prepared under the direction of O. E. MEINZER and L. K. WENZEL. [Price 75 cents.] Water-Supply Paper No. 861. *Surface Water Supply of the United States*, 1938. Part 11. *Pacific Slope Basins in California.* [Price 40 cents.] Washington: Superintendent of Documents.

Vapour Charts and Special Tables for Turbine Calculations. By PROFESSORS F. O. ELLENWOOD and C. O. MACKEY. New York: John Wiley and Sons, Incorporated. London: Chapman and Hall, Limited. [Price 15*s.* net.]

Applied Economics for Engineers. By BERNARD LESTER. New York: John Wiley and Sons, Incorporated. London: Chapman and Hall, Limited. [Price 24*s.* net.]

Organising and Financing Modern Business. By PROFESSOR CALVIN CRUMBAKER. New York: John Wiley and Sons, Incorporated. London: Chapman and Hall, Limited. [Price 22*s.* 6*d.* net.]

Route Surveying. Second edition. By PROFESSORS G. W. PICKELS and C. C. WILEY. New York: John Wiley and Sons, Incorporated. London: Chapman and Hall, Limited. [Price 21*s.* net.]

Houseland Physics. By W. G. WHITMAN. Third edition. New York: John Wiley and Sons, Incorporated. London: Chapman and Hall, Limited. [Price 18*s.* net.]

Johnson's Materials of Construction. Eighth edition, rewritten and revised. By PROFESSOR M. O. WITHEY and JAMES ASTON. New York: John Wiley and Sons, Incorporated. London: Chapman and Hall, Limited. [Price 36*s.* net.]

Special Library Methods: An Introduction to Special Librarianship. By J. L. THORNTON. London: Grafton and Co., 51, Great Russell-street, W.C.1. [Price 10*s.* 6*d.* net.]

PERSONAL.

MESSRS. J. H. FENNER AND COMPANY, LIMITED, Hull, announce that they have appointed MESSRS. NORMAN BELL AND COMPANY (PTY.), LIMITED, electrical and mechanical engineers, Brisbane, to be their agents for the sale of Fenner Vee-rope drives, and other products, in Queensland, Australia.

MESSRS. THE ANGLO-SAXON PETROLEUM COMPANY, LIMITED, 110-113, Tavistock-road, Plymouth, inform us that MR. C. ZULVER, their former marine superintendent, retired on April 30 after 30 years' service. They have appointed MR. JOHN LAMB, A.M.I.Mech.E., M.I.Mar.E., marine superintendent in succession to Mr. Zulver.

MESSRS. BRITISH TIMKEN, LIMITED, Cheston-road, Aston, Birmingham, have acquired a controlling interest in MESSRS. FISCHER BEARINGS COMPANY, LIMITED, Upper Villiers-street, Wolverhampton. MR. MICHAEL DEWAR, chairman of Messrs. British Timken, has assumed the chairmanship of Messrs. Fischer Bearings Company. The election of Mr. Dewar and of MR. F. J. PASCOE, financial director of Messrs. British Timken, to the board of Messrs. Fischer Bearings Company, was announced in our columns on page 386, *ante*.

MR. CYRIL BRAY, who is secretary of the File-Trade Export Group and of the Hacksaw-Trade Export Group, Norris Deakin Building, Sheffield, 1, has succeeded Mr. A. H. Plews as secretary of the Cutlery Export Group. Mr. Bray has also succeeded Mr. J. Ridyard as secretary of the Saw-Trade Export Group.

MR. L. G. REID, general manager of Messrs. The Brush Electrical Engineering Company, Limited, has been appointed to the board of Messrs. Brush Coachwork, Limited, Loughborough.

LIEUT.-GENERAL SIR RONALD CHARLES, K.C.B., C.M.G., D.S.O., has been appointed Chief Royal Engineer of the Corps of Royal Engineers in succession to the late GENERAL SIR BINDON BLOOD, G.C.B., G.C.V.O.

TENDERS.

WE have received from the Department of Overseas Trade, Great George-street, London, S.W.1, particulars of the undermentioned tenders, the closing dates of which are as stated. Details may be obtained on application to the Department at the above address, quoting the reference numbers given.

Low-Tension Switchboards. Ten metal-clad, 380/220 volts, 50-cycle, oil circuit-breaker switchboards, rupturing capacity to be not less than 22,000 amperes (R.M.S.). City Council, Johannesburg, South Africa; July 10. (T. 19,395/40.)

Voltage-Regulating Equipment, three-phase, oil-immersed, self-cooled, outdoor-type, for use on a 20,000-kVA, 70-kV, 50-cycle circuit. State Electricity Commission of Victoria, Melbourne; July 23. (T. 19,531/40.)

Pumping Equipment. With reference to the call for tenders for centrifugal dock pumps, unchokeable centrifugal pumps, pump valves, drainage pumps, pipework, electric motors, and control gear, noted on page 522, *ante*, we now learn that the Chief Controller of Stores, Mechanical Section, Indian Stores Department, New Delhi, has postponed the closing date from June 1 to June 22. (T. 19,413/40.)

Suspension-Type Insulators, extra-high tension, 1,725 strings (7 units per string) for use on a 110-kV, 50-cycle transmission line. Public Works Department, Wellington, N.Z.; June 25. (T. 19,809/40.)

Sewer Pipes and Fittings, salt-glazed ware. City Council, Johannesburg; June 19. (T. 19,833/40.)

BALL AND ROLLER-BEARING DATA.—The catalogues of ball bearings issued by Messrs. The Hoffmann Manufacturing Company, Limited, Chelmsford, have contained for some years a useful section summarising the methods of calculating the loads on bearings in mechanisms of various types. In the latest edition, No. L C 10, this section has been amplified by the addition of notes on epicyclic gears. A graphical method of selecting angular-contact bearings for combined thrust and journal loads is also included, and scales are given which enable the equation $x = \sqrt{a^2 + b^2}$ to be evaluated by direct measurement. Separate sections deal with the mounting and lubrication of ball and roller bearings. The appropriate maximum speeds for standard journal bearings with grease lubrication are plotted graphically. A concluding section of tables includes fit allowances for shafts and housings, the limits of manufacturing accuracy, etc., and lists of the symbols standardised by the British Standards Institution for ball and roller bearings of the various standard types, with the corresponding references to the Hoffmann standard sizes.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Welsh Coal Trade.—Every effort was made to increase this district's coal output during the past week and the steps taken towards this end were the chief centre of interest on the Welsh steam-coal market. Mr. D. R. Grenfell, the new Secretary for Mines, in a broadcast address in Welsh, appealed for greater production. He said that they were preparing this year for an output of 200,000,000 tons for internal consumption. It was announced during the week that the Tirbach Colliery at Ystalyfera, in the Swansea Valley, which had been closed down for several months, was being restarted as a result of the action taken by Lord Portal, Chairman of the Production Council and the Mines Department. Operators again encountered a brisk demand from both home and overseas customers. The amount of new business that could be concluded, however, remained very limited. Practically the whole of collieries' present outputs were being used to fulfil contract commitments and these, as a rule, were sufficient to ensure the steady absorption of potential outputs for some time to come. Forward business was consequently not easy to negotiate and the market as a whole again presented a very firm tone. The popular duff coals remained the outstanding feature of the market and were in brisk request. Outputs of these kinds, however, were well sold ahead and what occasional odd parcels did become available for early shipment were quickly taken up at high figures. Sized and large kinds were well provided with outlets for some months to come, while the small grades were only sparingly available. The demand for cokes from inland users was maintained but supplies were scarce and the tone firm. Patent fuel was in good demand.

The Iron and Steel Trade.—Active conditions were again in evidence in the iron and steel and allied trades of South Wales and Monmouthshire. The demand for the various finished products was sustained and with producers generally holding well-filled order books, works were engaged practically to full capacity.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—All steel and engineering firms in this area worked continuously over the week-end. In the past, activity ended at two o'clock on Saturday afternoon, and a resumption was not made until ten o'clock on Sunday night, but plants will, in future, operate without a break on Saturdays and Sundays. The works are handling a surprisingly large volume of ordinary commercial business; many orders are on hand from abroad. Among the latest overseas inquiries received by the Sheffield Chamber of Commerce are:—From Cairo for tools; from Montevideo for agricultural steel and tools; from Australia for corn-mill plant; from Turkey for tools for wood and metal work, and valves and appliances for steam, water, and gas plants and undertakings; and from Spain for tools and files. In the raw and semi-finished steel-melting branches intense activity prevails, and outputs are reaching record dimensions. The demand for steel bars and billets is exceptionally large, while steel sheets and strip are active media. Structural-steel makers report further progress. Makers of all types of steelworks' and ironworks' machinery and related equipment continue to benefit from extension schemes in various parts of the country. The demand for high-efficiency steels is so extensive in range that producers are considering plans for installing additional electric furnaces. Machinery used in the production of tools and small machine parts is also in strong demand. Sheffield firms continue to carry on extensive trade with South Africa, South America, New Zealand, and India, in grinding and crushing machinery, and especially in equipment used by gold and silver mines. Makers of agricultural machinery and parts report that no difficulty is being experienced in obtaining adequate supplies of steel. The trade in such products has been one of the best for many years. Intense activity prevails in tool manufacture.

South Yorkshire Coal Trade.—Efforts are being made by owners and miners' representatives to increase outputs. The Yorkshire District Joint Coal Committee, comprising owners and men, have decided to place a notice at every pithead in Yorkshire appealing for increased output. The demand for industrial coal shows a further increase. Electricity and gas undertakings are taking heavy tonnages of smalls and slacks, and house coal is active considering the time of the year. The coke market is exceptionally favourable.

THE UNITED STATES COLLIERY INDUSTRY.—The average daily output of bituminous coal in the United States, during the week ending May 4, was 1,332,000 tons, compared with 1,307,000 tons in the preceding week.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—There is practically nothing fresh to record in connection with the Scottish steel trade this week. All available plant is being kept running at full capacity in order to cope with the demands for material. Steady pressure for deliveries is general. The shipyards are consuming large tonnages of steel, and structural sections are in great request. A reasonable amount of steel is being earmarked for general home trade. The raw material position is satisfactory. The following are the current quotations:—Boiler plates, 13*l.* 8*s.* per ton; ship plates, 12*l.* 10*s.* 6*d.* per ton; sections, 12*l.* 8*s.* per ton; medium plates, $\frac{3}{16}$ in. thick, weighing 6 lb. or more per square foot, 14*l.* per ton, and weighing under 6 lb. but not less than 4·81 lb. per square foot, 14*l.* 10*s.* per ton; black-steel sheets, No. 24 gauge, in 4-ton lots, 17*l.* 10*s.* per ton; and galvanised corrugated sheets, No. 24 gauge, in 4-ton lots, 20*l.* per ton, all delivered at Glasgow stations.

Malleable-Iron Trade.—In the West of Scotland malleable-iron trade the demand continues and the majority of the works are fully occupied. The re-rollers of steel bars are still extremely busy and are working at high pressure to fulfil the urgent orders now on hand. Their stocks of raw materials are very satisfactory. Arrangements have been made by the British Iron and Steel Federation for a considerable increase in the shipment of semies from the United States. It is not anticipated that there will be any slowing down in production. The current prices are as follows:—Crown bars, 14*l.* 2*s.* 6*d.* per ton; No. 3 bars, 12*l.* 10*s.* per ton; No. 4 bars, 12*l.* 15*s.* per ton; and re-rolled steel bars (tested), in 4-ton lots, 14*l.* 3*s.* per ton, all for home delivery.

Scottish Pig-Iron Trade.—No change has taken place in the Scottish pig-iron trade since our last report and every ton produced goes quickly into consumption. Steelmakers are pressing for supplies and a large tonnage is going to the heavy foundries. It is of interest to note that makers of light castings in the Falkirk district are likely to be much busier in the near future as arrangements have been made for them to undertake some special work in order to compensate for the quietness which followed the slowing down in the building trade after the outbreak of war. The following are to-day's market quotations:—Hematite, 6*l.* 7*s.* 6*d.* per ton, and basic iron, 5*l.* 4*s.* 6*d.* per ton, both delivered at the steel works; foundry iron, No. 1, 5*l.* 15*s.* per ton, and No. 3, 5*l.* 12*s.* 6*d.* per ton, both on trucks at makers' yards.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—The Council of the Institution of Electrical Engineers has awarded a number of premiums to the authors of papers read or accepted for publication during the 1939-40 session. These include the Institution Premium to Mr. G. F. Sinclair; the Ayrton Premium to Messrs. G. T. Winch and A. M. Midgley; the Fahie Premium to Mr. H. H. Harrison; the John Hopkinson Premium to Mr. W. D. Horsley; the Kelvin Premium to Dr. T. L. Eckersley, F.R.S.; the Paris Exhibition (1881) Premium to Dr. B. P. Dudding, M.B.E., and Mr. W. J. Jennett; and Overseas Premiums to Mr. J. R. Brookman and to Messrs. G. Babat and M. Losinsky.

ELECTRIC LIGHT FITTINGS EXPORT GROUP.—An Electric Light Fittings Export Group has been set up for the purpose of controlling material and co-ordinating individual effort to increase export business in electric light fittings in furtherance of the national export drive. The chairman of this group, which has received the official recognition of the Export Council of the Board of Trade, is Mr. A. E. Iliffe, while the secretary is Mr. F. A. Rogers, 36, Kingsway, London, W.C.2. We are asked to state that membership of the group is open to manufacturers in Great Britain of electric light fittings and fittings accessories, who are at present exporting their products or definitely intend doing so.

IRON AND STEEL CONTROL.—The Minister of Supply has issued Direction No. 2, dated May 25, 1940, under the Control of Iron and Steel (No. 8) Order, 1940. The Direction substitutes new schedules of sheet prices for those hitherto ruling, the effect of which is to provide a special price for thick sheets or light plates, 3 mm. thick and over, when these are rolled on a sheet mill. The demand for this class of material is such that it is necessary to obtain production in sheet mills which do not normally roll these thicknesses. In future, the maximum price, and extras, for sheets or plates, 3 mm. thick and over, when wholly rolled down in a sheet mill, will be the same as that for sheets immediately below 3 mm. Other prices, including the price of light plates, rolled in plate mills and the prices of plates and sheets, however made, from merchants' stocks, are unaltered. Copies of the Direction may be obtained from H.M. Stationery Office, York House, Kingsway, London, W.C.2.

NOTICE OF MEETING.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

PHYSICAL SOCIETY.—Friday, June 7, The Imperial College, Imperial Institute-road, South Kensington, S.W.7. 5 p.m., Extraordinary General Meeting. 5.15 p.m., Annual General Meeting. (i) Annual Report of the Council. (ii) Presidential Address, "Some War-Time Reflections," by Professor Allan Ferguson.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—A further increase in the aggregate tonnage output of iron and steel still leaves little additional tonnage for ordinary industrial purposes. Under the control of distribution scheme, orders are being placed according to productive capacity and the operation of the system promises to ensure an equitable arrangement of deliveries.

Cleveland Iron Trade.—While an appreciable improvement in orders for iron castings can be reported, the consumption of foundry pig iron is still below the normal. The stocks of pig are small, and the local make is still of an intermittent character. The supply of Midland iron, however, is maintained on a satisfactory scale and ample tonnage continues to reach North of England foundries. Stabilised quotations of Cleveland pig are at the level of 111*s.*, delivered within the Tees-side zone.

Hematite.—There is little East Coast hematite stored at makers' yards, and the heavy production is rapidly absorbed. The statistical position is receiving careful attention and preparations are being made for an enlargement of output. Buyers are extensively covered, but are anxious to place new orders; the requirements of producers' own consuming departments, however, are increasing. Little business is passing through merchants' hands. The recognised market values are at the equivalent of No. 1 grade of hematite at 127*s.* 6*d.*, delivered to North of England areas.

Basic Iron.—As the whole of the production of basic iron continues to be taken up by the requirements of makers' adjoining steelworks, there is still no saleable tonnage and the quotation remains nominal at 104*s.* 6*d.*

Foreign Ore.—Stocks of foreign ore are considerable and imports continue to arrive quite satisfactorily.

Blast-Furnace Coke.—Conditions in the blast-furnace coke branch of trade are unchanged. Local users have little occasion to buy and sellers are disinclined to add to their extensive contract obligations. The fixed prices of Durham coke remain on the basis of good medium qualities at 31*s.* 8*d.* at the ovens.

Manufactured Iron and Steel.—Deliveries of semi-finished iron and steel are at a rate that keeps the mills of re-rollers well employed. Finished-iron firms are gradually turning out increasing tonnages, but further expansion in the demand would be welcome. Finished-steel producers are heavily sold and in arrears with deliveries. The supply of material for shipbuilding, however, is better than had been expected. The delivery of sheets is also satisfactory.

Scrap.—All grades of heavy steel and foundry scrap are in demand. Some improvement in deliveries can be recorded, but available parcels are promptly purchased at the maximum control prices.

THE INSTITUTE OF BRITISH FOUNDRYMEN.—The 37th annual Conference of the Institute of British Foundrymen will be held at Cheltenham on Friday and Saturday, June 7 and 8. The whole of the first day will be devoted to Council and Committee meetings and the Conference proper will commence in the Town Hall at 9.30 a.m., on June 8, when, after a civic welcome, two simultaneous discussion sessions will be held. The papers to be discussed in session A will comprise: "Chromium-Alloy Heat-Resisting Cast Iron," by Mr. R. C. Tucker; "The Production of Pressure-Resisting and High-Duty Iron Castings," by Mr. J. L. Francis; "Gates and Risers for High-Shrinkage Alloys in High-Test Cast Iron," by Messrs. A. E. Cartwright and C. C. Brisbois; and "The Extended Use of Cast Iron with Special Reference to War Conditions," by Mr. J. G. Pearce. Session B will comprise three papers, namely, "The Design of Test Pieces for Carbon-Steel Castings," by Messrs. C. H. Kain and E. W. Dowson; "Gas in Liquid Cast Iron," by Mr. W. Y. Buchanan; and "Observations on Contraction in Cast Iron," by Mr. E. Longden. A luncheon, at 1.30 p.m., and a dinner, at 7.30 p.m., have been arranged to take place at the Plough Hotel, High-street, Cheltenham. The afternoon of June 8 will be free.

THE DERBY BATHS OF THE BLACKPOOL CORPORATION.

MR. JAMES DRAKE, A.M.INST.C.E., BOROUGH ENGINEER AND SURVEYOR.

(*For Description, see Page* 553.)

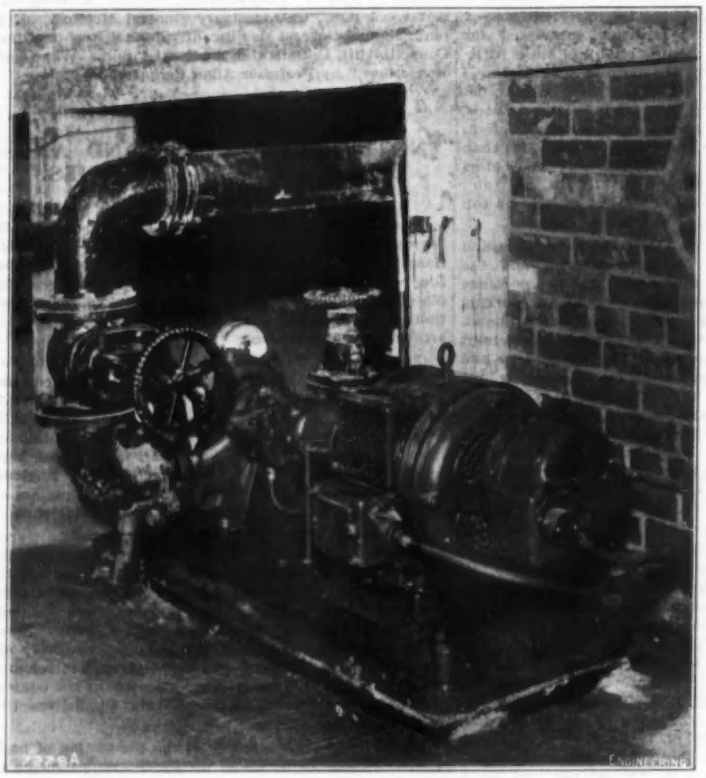


FIG. 1. 10-H.P. SPRAY-RAIL BOOSTER PUMP.

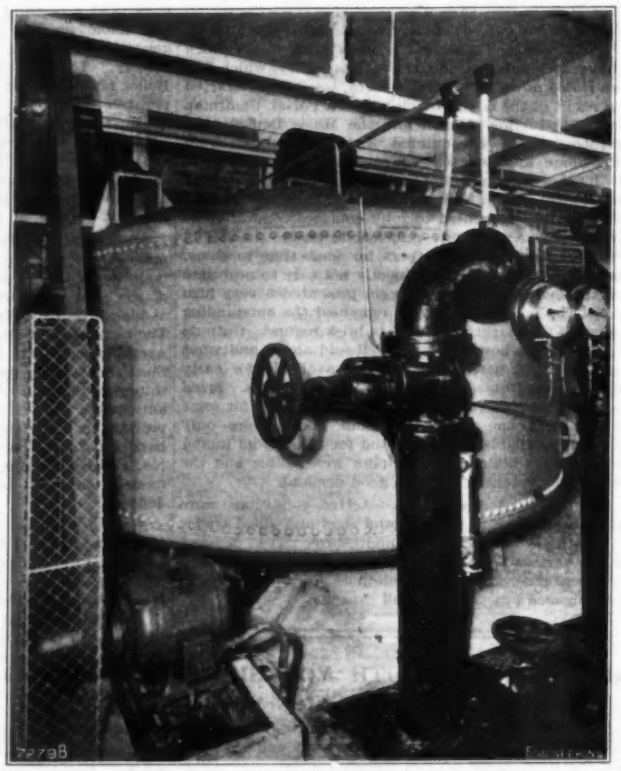


FIG. 2. FILTER TANK AND AGITATOR.

THE NEWCOMEN SOCIETY'S SUMMER MEETING.

THE Council of the Newcomen Society have decided to follow the usual practice of holding a summer meeting in June, but, on account of present circumstances, the programme will be considerably restricted by comparison with those of former years. The meeting will occupy the two days, Thursday and Friday, June 13 and 14, and will be held in London and its environs. The party will assemble at 9.45 a.m. on June 13 at the Institution of Mechanical Engineers, and will proceed thence by motor coach to the Grove Works of Messrs. John Smith and Company, engineers, at Carshalton, the power for which is provided by an overshot water-wheel and a grasshopper engine. The route of the Surrey Iron Railway (1801) will be touched at points on the journey. In the afternoon, the members will visit the National Maritime Museum at Greenwich, where they will be received by the Director, Sir Geoffrey Callender, M.A.

The programme for Friday, June 14, includes, in the morning, visits to Messrs. Francis Higgins and Son, Limited, manufacturing silversmiths, of Newman-street, W.1, and Messrs. W. and C. Nightingale, bedding manufacturers, of 70, Old-street, E.C.1, where a beam engine provides power to drive the works machines. In the afternoon, the party will proceed by motor coach to the Abbey Folk Park at New Barnet, where they will be received by the Director. The meeting will terminate when the party returns to the Institution of Mechanical Engineers, Storey's-gate, S.W.1. Notifications by members (who may bring guests) of their intention to take part in the meeting should be sent, not later than June 7, to the assistant secretary, Miss G. Bingham, O.B.E., 43, King's-road, London, S.W.3.

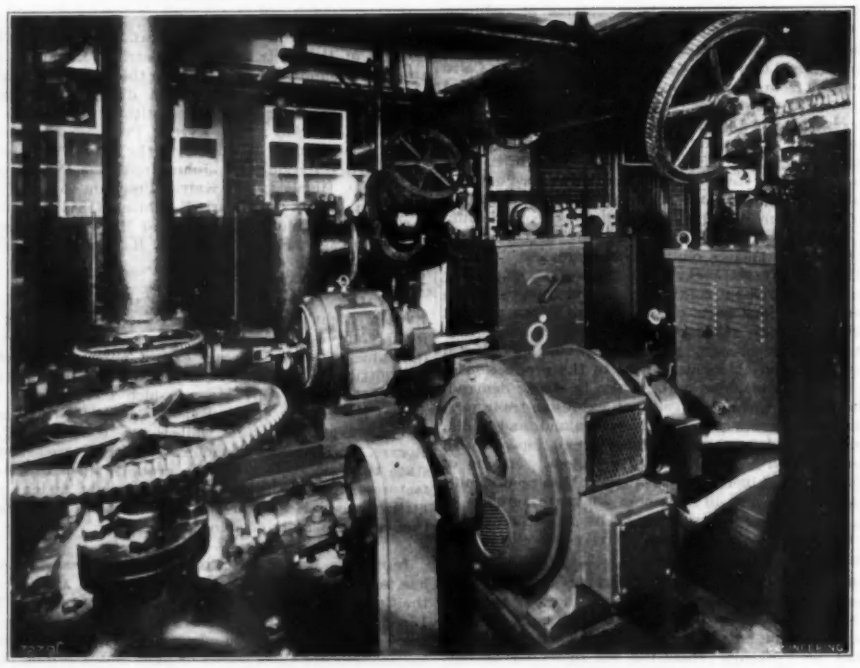


FIG. 3. FILTER-ROOM PUMP FOR MAIN BATHS.

SYDNEY HARBOUR BRIDGE.—It is stated in a recent issue of *The Commonwealth Engineer* that during the last three years the Sydney Harbour Bridge has shown a surplus revenue of 94,059*l.* after meeting all charges. The traffic over the bridge has grown steadily since its opening, the total number of railway, tramway and omnibus, and road-vehicle passengers increasing from 28,459,000 in the first full year, 1932-33, to 43,434,000 in 1938-39.

CALVERT'S MECHANICS' YEAR BOOK.—This practical little handbook, which incorporates *Calvert's Mechanics' Almanack*, with the 1940 issue now reaches its 65th year of publication. Although it still contains a judiciously selected quota of tables, a large part of the space is occupied by short, but clearly illustrated, descriptions of easily made and applied workshop apparatus and tool equipment, and by workshop hints, recipes, and suggestions. The issue has, of course, been revised where necessary, and has also been amplified, a section on sheet-metal working forming an example of the added matter. The field covered is very wide and the book should be serviceable, apart from its utility in the workshop, to the handy-man and the maintenance engineer. The publishers are Messrs. Sherratt and Hughes, Saint Ann's Press, Timperley, Cheshire. The price remains the same as in previous years, namely, 6*d.* net., or 8*d.* including postage.

TELEGRAM-FORM CONVEYING SYSTEMS; GENERAL POST OFFICE.

COLONEL A. S. ANGWIN, D.S.O., M.C., M.I.E.E., ENGINEER-IN-CHIEF.

(*For Description, see Page* 535.)

FIG. 40. PNEUMATIC-TUBE TABLE; CENTRAL TELEGRAPH OFFICE.

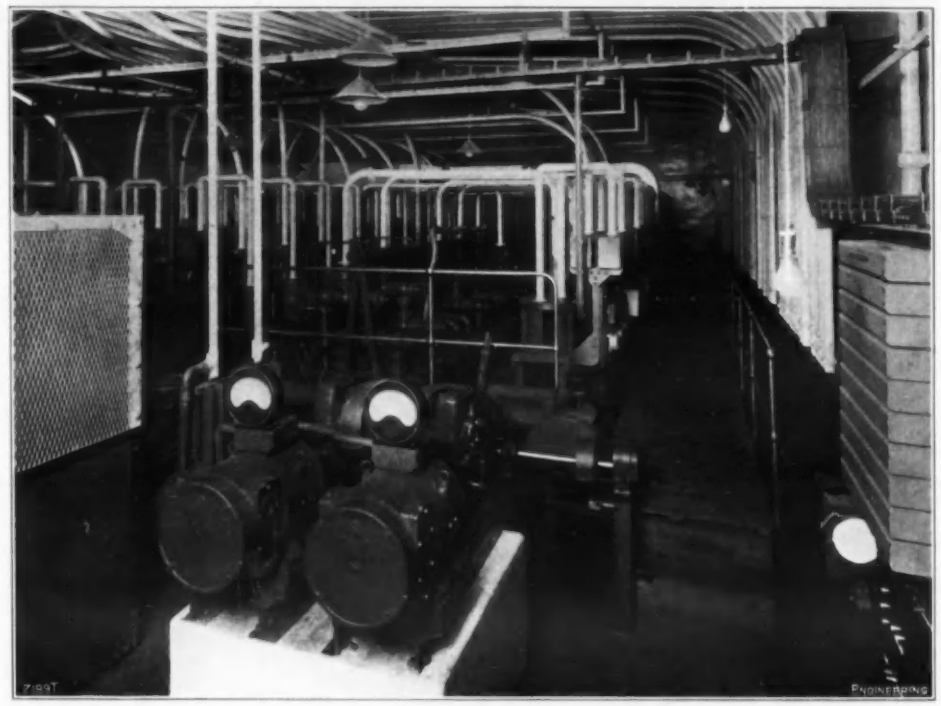


FIG. 41. AUTOMATIC PNEUMATIC SWITCH ROOM; CENTRAL TELEGRAPH OFFICE.

Fig. 42.

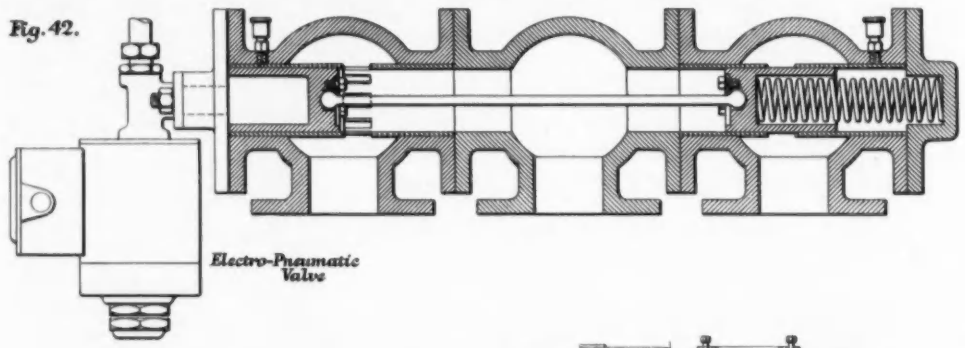
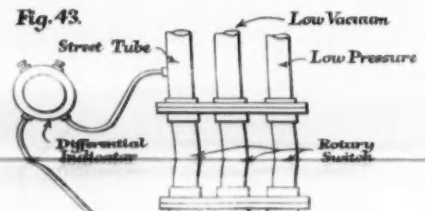


Fig. 43.



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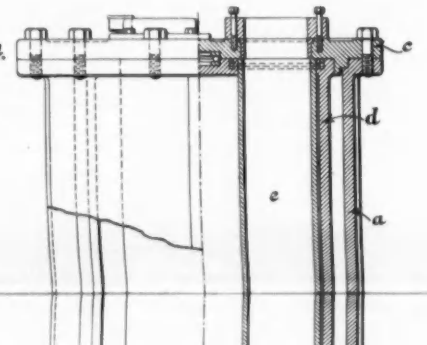

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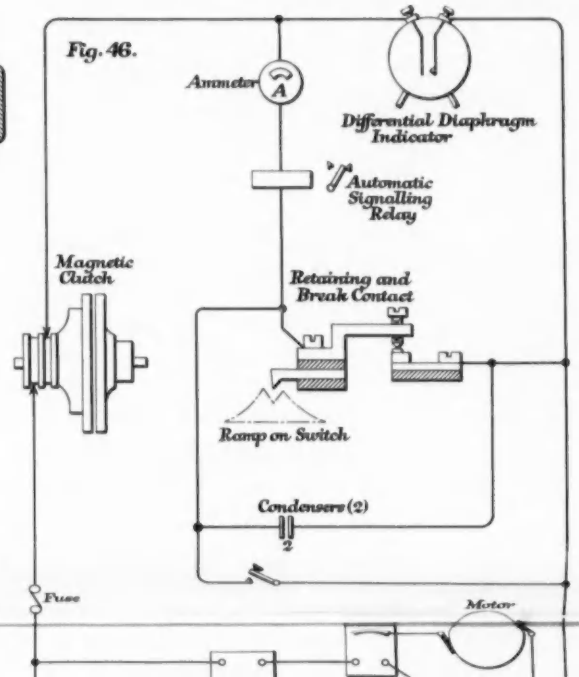

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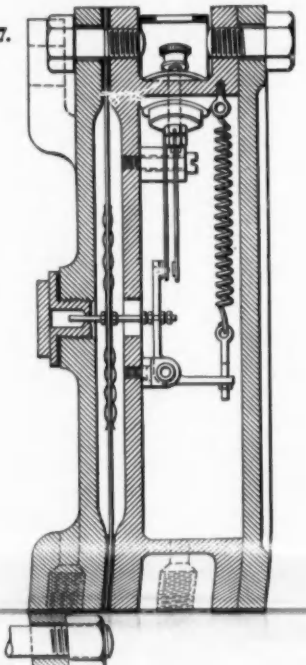

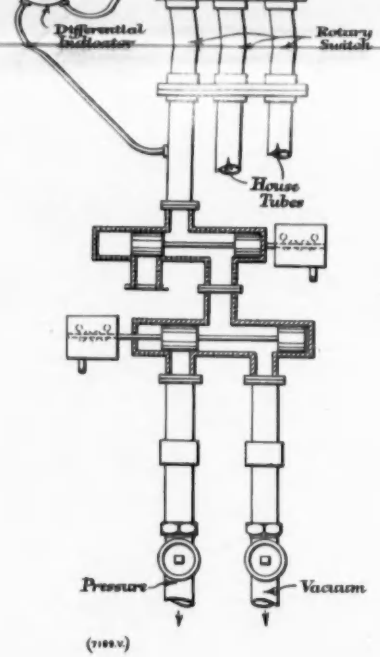

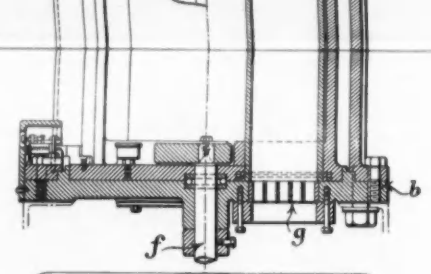

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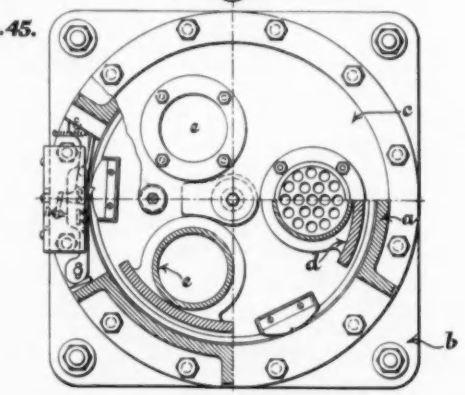


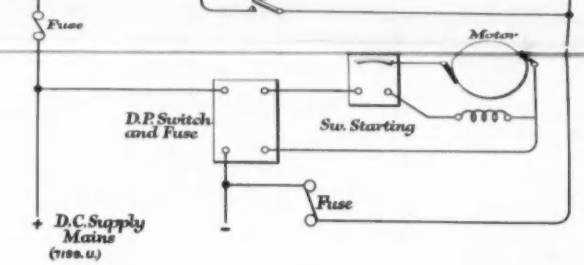


Fig. 48.

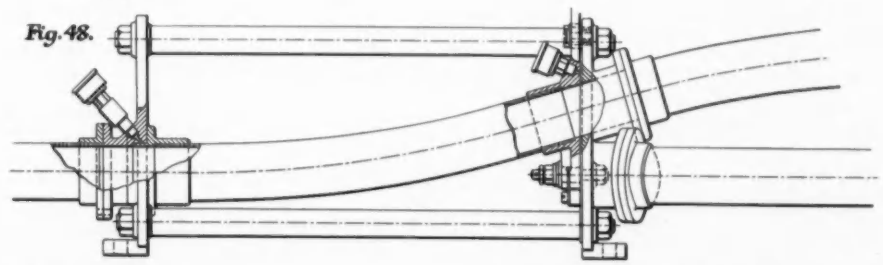


Fig. 49.

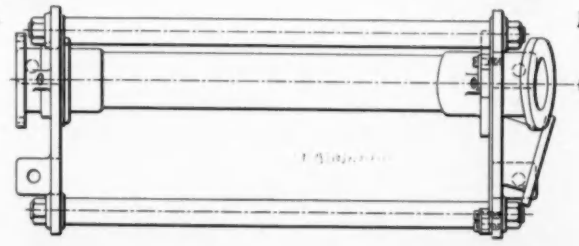
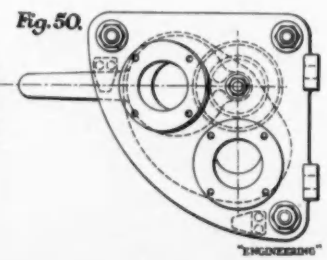


Fig. 50.



"ENGINEERING"

Fig. 51. Rotary Switch for Pneumatic Tubes.

Fig. 52. Relay Panel for Rotary Switches.

Fig. 53. House Pneumatic Tubes During Erection.

ENGINEERING.

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ADVERTISEMENT RATES.

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines, or under, and one shilling per line up to one inch. The line averages six words. When an advertisement measures an inch or more the charge is 12*s.* per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns, of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but cannot be guaranteed.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be delivered not later than first post on Wednesday. Alterations to standing advertisements must be received at least 10 days previous to the day of Publication. Passed proofs must be in our hands by Saturday morning, otherwise they will be taken as correct. The proprietors will not hold themselves responsible for blocks left in their possession for more than two years.

All accounts are payable to "ENGINEERING," Ltd. Cheques should be crossed "The National Provincial Bank, Limited, Charing Cross Branch." Post Office Orders should be made payable at Bedford Street, Strand, W.C.2.

TEMPORARY ADDRESS.

For the duration of hostilities, the Editorial and Publishing business of this Journal is being conducted from 18 and 20, Compton Road, Hayes, Middlesex. The Telephone Number of the Editorial Department is Hayes 1730, and that of the Publishing Department, Hayes 1723. The Bedford Street Offices are open on Fridays only, between 10 a.m. and 5 p.m., for the distribution of the current issue and for retail sales.

CONTENTS.

	PAGE
Telegram-Form Conveying Systems; General Post Office—III. (*Illus.*)	535
Power-Plant Standardisation	538
Some Effects of Short-Circuits on Three-Phase Transmission Lines (*Illus.*)	539
Notes on New Books	540
"Geometric" Jig-Boring Machine (*Illus.*)	541
British Standard Specifications	542
Books Received	542
Personal	542
Tenders	542
Notes from the South-West	543
Notes from South Yorkshire	543
Notes from the North	543
Notice of Meeting	543
Notes from Cleveland and the Northern Counties	543
The Newcomen Society's Summer Meeting	544
The Sixth Column	545
Mercury-Arc Rectifiers in the Coal-Mining Industry	546
Notes	546
The Institute of Metals	547
The Industrial History of Sweden	548
The American Society for Testing Materials	549
The Late Mr. W. V. Graham	550
The Late Mr. J. F. I. Thomas, O.B.E.	550
Diesel-Engine Driven Welding Set (*Illus.*)	550
Improvement of Works-Supply Power Factor	551
Labour Notes	551
Rolling Experiments with Ships and Models in Still Water (*Illus.*)	552
The Derby Baths of the Blackpool Corporation (*Illus.*)	553
Catalogues	554
"ENGINEERING" Patent Record (*Illus.*)	554

One Two-Page Plate.—TELEGRAM-FORM CONVEYING SYSTEMS; GENERAL POST OFFICE.

ENGINEERING

FRIDAY, MAY 31, 1940.

VOL. 149. No. 3881.

THE SIXTH COLUMN.

ON Saturday, May 25, Mr. Ernest Bevin, the new Minister of Labour and National Service, in his speech to the conference of the General Council of the Trades Union Congress and in his subsequent broadcast address, made an important contribution towards the intensification of the industrial efforts on which the ultimate victory must so largely depend. In saying this, we are not deluding ourselves with the idea that success will be attained by speeches. The previous holders of many of the ministerial posts which are directly concerned with the provision of armaments displayed no lack of verbal ability, but the steps which have had to be taken in the last fortnight show that their activity in this direction was not always followed by the fullest possible measures of a more material kind. The value of Mr. Bevin's contribution lay in the unmistakable advice, or rather instruction, which he addressed to organised labour and which, supported by the authority of his position and reputation, was at once freely accepted. His image of a sixth column—a National Service column—should be of direct practical value in making the men and women in the shops realise that the issue of this war depends on them, not less than it does on their sons and brothers in the armed forces.

As the Government now has complete authority over the activities of every individual in the country, it was able to order—not merely to request—that, for the present, munition factories should operate day and night and over the week-ends. The necessity for this step has been stressed many times in our columns during recent months, and the only alloy in our feeling of satisfaction that it has now been taken is that it has been unnecessarily delayed. Clearly, continuous activity of this kind cannot be maintained for extended periods without imposing considerable strain, both physical and mental, on the workpeople, and the general instruction under which the factories are now operating will no doubt be subject to adjustment in due course. For the present, however, the procedure is entirely justified, and requires neither apology nor explanation. Its effective prosecution in the shops will be greatly helped by Mr. Bevin's inspiring leadership.

As we have stated more than once, the possibility of practically continuous operation of armament factories over many months has already been demonstrated by practical examples. Some of our vital organisations have followed this regime since the beginning of the war, the procedure being to arrange for a week-end off every four weeks, the normal Christmas and Easter holidays not being interfered with. In the ordinary course, the Whitsuntide holiday would have been granted, but in view of the appeal which was made, even factories which had displayed this strenuous activity over many months were obliged to forgo this break. The inauguration of similar procedure in all munition factories will naturally take considerable time—frequently, for instance, catering and travelling arrangements for a new or a greatly increased night shift will have to be arranged, while in many cases the doubling of the labour force will have to be accomplished. It is particularly in the recruiting of the skilled labour, which must form the backbone of practically every engineering factory, that the great difficulty is likely to arise, and it would be well if the invitation of the Minister of Aircraft Production to skilled and semi-skilled workers in garages to transfer their activities to aeroplane building were replaced by a definite instruction. At present, these men hardly know what to do, having received opposite instructions from different authorities.

With the best will on every side, the immense movement of labour and its transfer to new types of activity is bound to give rise to innumerable minor hitches and difficulties, and the Labour Supply Board, which has been set up by the Minister of Labour, should be of great assistance in ensuring that as little energy as possible is dissipated by ill-directed enthusiasm and that our labour front shall be deployed to the best effect. It is to be feared that not all politicians realise that the carrying on of a large engineering factory is a highly technical operation, but the wise inclusion in the Labour Supply Board of Mr. K. C. Appleyard, managing director of the Birtley Company, and Mr. A. P. Young, manager of the Rugby works of the British Thomson-Houston Company, should ensure that the problems which will face the managements of the controlled factories shall be given proper attention. The labour force is an essential element in the production programme, but it is on the management that the responsibility for output ultimately falls.

This last consideration is one of great weight. Under their present powers, the Government may fill vacancies on the managerial side of any factory engaged on munitions by instructing any engineer in the country to report for duty on the job. These powers are useful—in present circumstances, probably essential—but it is clear that their operation in detail will raise problems of some difficulty. Not every member of the Institution of Mechanical Engineers is suitable for immediate transference to the supervision of a machine shop. A National Service register of members of the various technical institutions was compiled by the Ministry of Labour before the war, but, as we pointed out last week, insufficient use appears to have been made of it. As this register contains information about the careers and experience of those whose names it includes, it would appear to be the obvious source of reference for those who are responsible for staffing factories of which either the area, or the hours of work, are being extended. It is a matter for additional satisfaction, therefore, that those registered are now requested to send a postcard to the Ministry of Labour, advising if they are immediately available for work of national importance.

It must be regretted that this step, like many others, was not taken by those who were responsible for the activities of the Ministry of Labour in the past. In view of the vital part which the professional engineer is playing, and to an ever-increasing extent will play, in the home activities of the war machine, it would appear that this register might have been analysed months ago, the names of likely men

for each particular type of activity being tabulated so that, in the present emergency, the Ministry might address itself directly to those whose services would be useful in some particular sphere. So many engineers, in their private capacity, or owing to the activities of their firms, have turned over to war work in the last few months that it is too much to expect that the register could record the present activity of every engineer whose name it contains; but, none the less, such an analysis would have saved much time and prevented many fruitless inquiries at the present time. In the circumstances, the postcard return is probably the best immediate procedure which could have been devised. A possible disadvantage is that the Minister may receive such an overwhelming reply to his invitation that he may find difficulty in dealing with it; but it may be safely prophesied that Mr. Bevin will find that professional engineers, on whom the successful utilisation of his labour force so largely depends, will not fail him.

MERCURY-ARC RECTIFIERS IN THE COAL-MINING INDUSTRY.

In the days when the relative merits of the alternating and direct-current systems were a favourite subject for debate, it used to be argued by those who favoured the latter that, at least, it facilitated the application of electricity for power purposes. The direct-current motor, they said, was a more highly developed and simpler piece of apparatus and had the advantage that its speed could be easily regulated over a wide range. On the other hand, it cannot be denied that, at that time, the state of alternating-current motor design was embryonic, compared with its present state of development, and that solutions of the difficulties of speed control and starting had not then been discovered. Moreover, a large and influential school of thought believed that the proper method of supply was to employ alternating-current generation with direct-current distribution.

For a time it seemed as if, great as the advantages of the alternating-current system were, it would have a fierce competitor in the direct-current motor, and that the competition would be increased as the use of electricity for power purposes developed. Actually, the reverse has been the case. The concentration of electrical generation in a few large stations, the ease with which alternating-current pressures can be transformed, the improvements which have taken place in the alternating-current motor, and the increasing use of electricity for all purposes, have all combined to drive the direct-current system into a position almost approaching insignificance. Two examples only need be given in proof of this. Of the 8,913,478 kW of generating plant installed in the public-supply stations of the country in 1937-38, only 205,462 kW was providing direct-current; and, of the 2,243,987 h.p. of electric motors in British mines in 1938, 85 per cent. were alternating current. The percentage of those using direct current has fallen steadily for some years.

Nevertheless, there are indications that the time has come when the direct-current motor is beginning to make up some, at least, of the lost ground, and is taking a greater share in the development of electric power. In fact, as Mr. G. A. Juhlin recently pointed out, there has been a noticeable increase in the demand for direct-current motors during the last few years, and this increase is occurring throughout most of the industries using electric power. The explanation probably lies in the complex nature of modern industrial processes, which require variable speeds and the economic advantages obtainable therefrom. The result is that Ward-Leonard equipments are being applied in many cases down to ½ h.p. for special machine tools; while boiler-house auxiliary drives especially are providing an increasing outlet for direct current.

While, however, the Ward-Leonard system gives excellent results, especially where co-ordinated control is required, it is, of course, not without its complications. It is probable, therefore, that another reason for the growing employment of the direct-current system and of the increasing use which is being made of its advantages is to be found in the development of the mercury-arc rectifier. It has been pointed out more than once that the extensive application of this form of power for traction purposes on the main lines of the Southern Railway was only rendered possible by the availability of this equipment. It is also highly probable that the employment of unit direct-current motors on machine tools, and for other purposes where close speed regulation is essential, is due to the same reason. This is the more likely to be the case now that the introduction of the low-voltage Ignitron rectifier makes the use of safer pressures possible at points where the employment of the more general 440 volts is accompanied by some risk.

In considering this subject, a paper on "Mercury-Arc Rectifiers in the Coal-Mining Industry," which was recently read before the American Institute of Electrical Engineers by Mr. D. E. Renshaw, is of interest. In the United States, direct-current is used in mines to a greater extent than it is here. The installation of converting plant to enable the necessary energy to be obtained from the alternating-current mains is therefore essential. During the past three years, the output of the rectifiers installed for this purpose has exceeded that of all other types of converting plant, and it seems possible that, with the increasingly rapid mechanisation of coal mining which is taking place, this trend is likely to be accelerated. As Mr. Renshaw points out, there are two reasons for this development. First, as we have said, there has been, in recent years, an increasingly rapid mechanisation, especially in the replacement of hand by machine loading; and, if this new plant is to pay for itself, it must be supplemented by a sufficient and efficient power supply.

The second, and perhaps more interesting, reason is the development of the Ignitron rectifier, which in other fields of utilisation is finding an increasing application in this country. Until a few years ago, only the multi-anode rectifier was available, and this, though highly suitable for traction purposes or where pressures higher than 500 volts were required, was not so applicable at lower voltage values. In Mr. Renshaw's opinion, it was not, in fact, until the Ignitron was developed for large capacities that rectifiers really became available to the coal-mining industry as a whole. Among the advantages of the rectifier is that it can be installed some distance away from the bottom of the shaft and that high-tension energy can, therefore, be taken farther into the workings than is otherwise possible. For instance, in a typical installation, a 300-kW rectifier supplied with three-phase current at 2,300 volts has been erected underground in a substation about 2 miles from the shaft bottom. Owing to the conditions in the haulage way, the design has been made very compact; no part is more than 55 in. high or 62 in. wide. On comparing the space thus occupied with any other form of direct-current converting plant, the advantages possessed by the rectifier are at once realised. This compactness has the further benefit of giving easy portability, with the result that in one mine it has been decided not only to place all the substations underground, but to make them portable. For this purpose, three trucks are used, the transformers and alternating switchgear being on one, the rectifier and its auxiliaries on the second, and the direct-current switchgear on the third. More recently a further step forward has been made by the use of permanently evacuated, permanently sealed rectifiers of the Ignitron type.

The principal advantages, of high momentary overload capacity and high efficiency, have combined, in many cases, to make the rectifier the most economical conversion unit. In a typical example of concentrated mechanical mining the substation is located near the centre of the load and serves several operating units, each of which consists of a cutter, a loader and a locomotive. These machines are equipped with intermittent or short-time rated motors, which the continuous ratings average about one-third of the nominal ratings. The capacity of the substation is sufficient to furnish all the power required on a continuous basis, and has sufficient momentary capacity to carry the peaks that may be experienced without damage to itself or interruption of the supply. These peaks are about equal to the aggregate rated capacity of the machines served. For example, a substation supplying six units requiring a total of about 960 kW should be capable of producing 900 kW momentarily and 300 kW continuously. Under the same conditions, 400 kW of converting plant would be required, as its overload capacity is less. Moreover, the electrical losses of a 300-kW rectifier are about 5 kWh per hour less than the losses of a rotary converter over the usual load cycle and 20 kWh per hour less than those of a synchronous motor-generator. In a mine where power must be continuously available to operate the pumps and other auxiliary services, the annual saving in comparison with a rotary converter would be 40,000 kWh, or 160,000 kWh in the case of a motor-generator. Further, a rectifier operates at an average load factor of 93 per cent., while a rotary converter, though capable of supply at a higher figure when on full load, is, for the greater part of the day, running at some lower load, with a corresponding falling off in efficiency. On the other hand, motor-generators can be designed to compensate the lagging power factor produced by inductive equipment on the system. In fact, where such correction is urgently required it may be advisable to install this class of equipment.

To sum up, experience shows that, in addition to their other advantages, rectifiers are at least equal to other types of converting plant in reliability, while their cost is either equal to, or less than, that of the more usual converting equipment. The operating cost is also less than that of rotating machinery, except where power-factor correction is of considerable importance. An analysis of load conditions is necessary to establish which type of equipment is most advantageous in particular cases, but it is obvious that the rectifier has many points which recommend it. The conditions present in mines impose a great strain on all electrical plant, and, to counteract this, much ingenuity in design and construction has been displayed. Similar attention must be paid to the manufacture of rectifiers for this purpose if the necessary safety is to be secured.

NOTES.

EXPORT TRADE IN INTERNAL-COMBUSTION ENGINES.

On page 363, *ante*, we recorded the formation of the Internal-Combustion Engine War Export Group, following on the recommendations embodied in the White Paper entitled "Aims and Plans of Work of the Export Council," published on March 6. It may be recalled that the aims and objects of the War Export Group were set out in a pamphlet known as the I.C.E.W.E.G. Red Book, published from the offices of the Group at 32, Victoria-street, Westminster, S.W.1. A supplement, known as Supplement No. 1, has now been published, and is obtainable from the same offices. The necessity for its publication arose partly from the desirability of defining the procedure of the Group in further detail, and partly from the fact that, since the Export Trade Materials Scheme of the I.C.E.W.E.G. was approved by the Board of Trade and by the Export Council in the form in which it appeared in the Red Book, the official responsibility of the Board of Trade in regard to the allocation of controlled materials to War Export Groups has been further extended and defined. In addition, the Industrial Supplies Department of the Board of Trade has since been organised. Generally speaking, the Board of Trade is now responsible for the allocation to the I.C.E.W.E.G. of the totals of controlled materials; the Chairman, for the apportionment among the members of the Group of the totals so allocated, and the Controllers, for regulating the supply to members of the materials subject to conditions set out in the supplement. It is advisable, therefore, that the contents of the latter should be carefully studied by every member of the Group. The main purpose of the supplement is to explain clearly to members the procedure they must adopt in order to secure materials under the scheme, and to obtain the full advantages which the scheme confers. It is pointed out that the procedure is an experimental improvisation; an attempt to surmount difficulties occasioned by the abnormal industrial and commercial conditions arising out of

the present war, and that no doubt when some experience of its practical operation has been gained, the need will be found for modifications and adjustments in some details. The major portion of the supplement is taken up with specimen forms of the type which must be used by the members, with detailed instructions for their completion. The successful and smooth working of the procedure must primarily depend upon each member of the Group making himself thoroughly acquainted with its provisions, and in particular, with the proper use and compilation of the forms.

Engineering and Atomic Transmutation.

The May Lecture of the Institute of Metals was delivered on Wednesday, May 8, by Professor J. D. Cockcroft, F.R.S., Jacksonian Professor of Natural Philosophy in the University of Cambridge, who had chosen as his subject "Engineering and Atomic Transmutation." In his lecture, which has now been published in the May issue of the *Journal* of the Institute, Professor Cockcroft gave an account of some of the apparatus installed in the new high-voltage laboratory of the Cavendish Laboratory. In describing the two-million-volt direct-current generator employed to speed up atomic projectiles for the transmutation of matter, he stated that electrically-charged projectiles, protons or deuterons, were produced by an electrical discharge, in ordinary or heavy hydrogen, and passed out, through a fine canal, into a long, evacuated porcelain tube, which acted as the atomic gun. There they were speeded up as they passed between pairs of cylinders connected to the high-voltage generator, each pair of cylinders having a potential of 200 kV across it, so that, in passing through eight stages, the particles were accelerated by a total potential of up to 1·6 million volts. The particles emerged from the accelerating tube into the research room below, where they were passed through a magnetic analyser which sorted out those of one type and of a sharply defined energy; they then passed on to strike the target under investigation. Apparatus of this type was of great utility as a precision tool for the exploration of nuclei. Unfortunately, it was of uncomfortably large dimensions. The two-million-volt set of the Cavendish Laboratory required a hall 80 ft. long by 40 ft. wide, and 50 ft. high; so that to proceed to higher voltages by this method was almost impossible financially. For generating particles of higher voltages, however, it was preferable to employ the cyclotron invented by Lawrence. The cyclotron produced particles of high energy by giving them a sequence of accelerations by the comparatively modest voltage of about 100,000, as they were whirled round between the poles of a powerful electromagnet. They received impulses in synchronism with their rotation and moved outward, along the path of a spiral, with increasing speed, so that, after 50 revolutions, they attained an energy of about 10 million volts and were then deflected out of the apparatus. The final limit of energy was set entirely by the size of the magnet, and, for the Cavendish and Liverpool magnets, this reached a value of about 10 million volts for deuterons. The geometric limit of energy for protons and α-particles was twice as great. The giant 250-ton cyclotron, at the University of Berkeley, California, and that under construction in the University of Birmingham, would generate deuterons of 25 million volts energy and α-particles of 50 million volts energy. Not content with this, a 2,000-ton cyclotron was under consideration, which should enable physicists to go well into the regions of cosmic-ray energies. The very high energy particles obtainable from the cyclotron were of the greatest importance in the production of artificial radioactivity on a large scale and had many other interesting applications.

Emergency Wireless Chain.

The maintenance of communication between various parts of the Empire is obviously essential at the present time and, so far as the interchange of information is concerned, radio telegraphy and telephony must admittedly play a great part in that maintenance. It is, therefore, satisfactory to learn from a statement made by Sir William Wilshaw, at a general meeting of Cables and Wireless, Limited, last week, that the necessary apparatus for establishing a colonial "wireless chain" was sent out from England early in the war. As these installations have been designed to provide an auxiliary service in cases of emergency or interruption, they should add greatly to the flexibility of the existing system. Apart from the benefit to the public, to trade, and to the Government, it requires little imagination to appreciate the importance of the scheme as a whole in the spheres of strategy and the safety of shipping. Sir Edward added that the performance of the apparatus had far exceeded expectations. It was available for any emergency for which it might be needed, as, indeed, had already been shown by events. The setting up of these sets enables some parts of the Colonial Empire to speak directly to each other for the first time. Newspapers in British Guiana, Grenada, Barbados, St. Lucia, St. Kitts, and elsewhere, have published accounts of talks carried on for the first time between islands of the West Indies group. Such a scheme is, of course, capable of further development and considering its convenience, reliability and, on the whole, freedom from interference, it is hoped that full advantage will be taken of it.

The Emergency Manufacture of Gauges.

It is becoming increasingly evident day by day that every ounce of effort of which this country is capable will have to be exerted to increase the output of munitions. One of the difficulties that must be overcome with the least possible delay is that of utilising the labour at present dispersed in what is, in the aggregate, a very large number of small workshops, garages, etc., each employing only a limited personnel. A valuable step in this direction has been the recent call to garage mechanics to volunteer for work in aircraft factories. This step, which met with immediate success, overcomes one of the basic difficulties so far as one class of workers is concerned, that of finding a type of work to which they can readily adapt themselves. It will be by no means easy, however, to ensure that the large body of skilled men who are at present working in small groups, or even individually, can be given work where their ability can be utilised to equal advantage; since, apart from tool setting and skilled machine-operating, for which, as a rule they are unsuited, the number of positions which they could occupy in a mass-production works is limited. What appears to be needed is their employment on work which can be produced economically and successfully in small workshops. Although the number of urgently-needed products of this type is probably limited, the wide extension of mass-produced munitions of all kinds affords the requisite opportunity in the concomitant heavy demand for gauges. Although the final processes of lapping and hardening even a simple gauge are highly-skilled work, the preliminary operations can be satisfactorily performed by persons possessing only a moderate degree of skill. The truth of this statement was amply illustrated in the last war, when the manufacture of gauges was undertaken on a considerable scale by the students in technical schools and instructional factories with very satisfactory results. The Government have recently issued an appeal for these establishments again to concentrate on this particular work, and there seems no reason why the appeal should not extend to the small factories and even to the private workshops of amateur mechanics and model-makers. Certain of the technical institutions and instructional factories, and a limited number of small firms, have the necessary skilled staff and equipment to carry out the final operations, and it would probably be advisable that they should concentrate entirely on this work, leaving the roughing out and intermediate processes to the less highly-skilled operatives.

The Purchase of American Machine Tools.

According to a circular issued by the Controller of Machine Tools, Ministry of Supply, on Tuesday, May 28, all future purchases of machine tools in the United States for British needs will be made by the British Supply Board in that country and Canada, acting through the British Purchasing Commission, whose office is at 15, Broad-street, New York City. Purchasers of machine tools will follow normal commercial practice in so far as contracts with agents are concerned. Agents are importers who have been registered under the new scheme at the Machine Tool Control, and they will provide purchasers with all the necessary advice, including information as to prices and delivery dates, and all customary pre-sale and post-sale service. On receipt of an order from a purchaser, the agent will forward it in duplicate to the British Purchasing Commission. Where a purchaser wishes to order machine tools for which there is no registered agent in the United Kingdom, he will transmit his order to the Controller of Machine Tools, Ministry of Supply, and not directly to the British Purchasing Commission. All orders must be sponsored by a Government Department, public-utility company or local authority. The object of these arrangements, which come into force on Monday, June 17, is to obtain the greatest possible delivery of machine tools with the minimum disturbance of prices and delivery dates. Any agent wishing to be registered under the scheme must, without delay, submit to the Controller of Machine Tools, Ministry of Supply, 35, Old Queen-street, London, S.W.1, two certified statements of the agency held by him, together with any necessary explanatory notes. The certified statement must indicate whether the agency mentioned is a sole agency or otherwise.

THE INSTITUTE OF METALS.

A general meeting of members of the Institute of Metals was held at the Institution of Mechanical Engineers, London, S.W.1, on the afternoon of May 8. The meeting was formally opened by the President, Lt.-Col. R. M. Preston, D.S.O., but, owing to pressure of other duties, he left immediately afterwards, and the chair was then taken by Dr. C. H. Desch, F.R.S.

The Crystallisation of Copper.

The first paper on the agenda bore the title "The Influence of Alloying Elements on the Crystallisation of Copper. Part II.—Large Additions and the Part Played by the Constitution." The author, Dr. L. Northcott, in presenting the contribution, stated that he had studied the tendency, towards columnar crystal growth, of alloys representing the binary systems of copper with aluminium, magnesium, manganese, nickel, phosphorus, lead, tin and zinc. The alloys had been cast into moulds designed to ensure uni-directional solidification, and, in many instances, it had been found possible to correlate the structures of the ingots with the constitution of the alloys. In general, alloys which froze at a constant temperature formed wholly columnar crystals, while the presence of a freezing range tended to reduce crystal length, although the various alloy systems behaved differently in this respect. The presence of a second phase in the alloy systems either increased or decreased the crystal length, depending upon the type of the constitution of the alloy. In general, the largest crystals had been found in the aluminium-copper series.

Dr. W. Hume-Rothery, F.R.S., who was one of the speakers in the discussion, said that it was not certain, in all the cases mentioned in the paper, how much of the foot of the ingot had been machined off. In some of the cases shown, the crystals seemed to start straight up from the foot of the mould, and in other cases there was a suggestion of a layer of small crystals on the surface, with larger crystals starting from them. This rather raised the question whether there were two types of columnar structure, or how much had been machined off. The next speaker, Dr. L. C. Bannister, said that the addition of copper to lead and its alloys was well known to have a restricting influence on grain growth, and its effect on cast lead was also known to most manufacturers of lead cable sheathing. It had been found that very small additions had a marked effect on the extrusion characteristics of lead, and the study of the effect of other metals, besides copper, on lead and zinc would be of great interest both theoretically and practically. Mr. A. J. Murphy, who spoke next, thought that it was

too early to look for a practical application of this work, and added that most of the systems with which the author had been concerned were not, in fact, used industrially. His object in speaking was to make a plea for the accumulation of much more experimental work in this new field before the results became burdened with too massive an edifice of theoretical reasoning. Dr. Northcott gave only a brief reply to the discussion, stating that he would amplify his remarks in writing.

STRUCTURE OF COLD-ROLLED AND ANNEALED COPPER.

The second paper considered at the meeting was entitled "The Structural Changes in Copper Effected by Cold Rolling and Annealing," and was by Dr. Maurice Cook and Dr. T. Ll. Richards. Dr. Cook, who presented the contribution, stated that a study had been made, by both X-ray and microscopic methods, of the structure of high-conductivity copper after different amounts of cold rolling up to a reduction in thickness of 97 per cent., and of corresponding material after annealing at temperatures of 550 deg. C. The material employed was a commercial copper of high-conductivity quality, having a copper content of 99·95 per cent., and containing, in addition, 0·03 per cent. oxygen; 0·003 per cent. silver; 0·005 per cent. iron; and less than 0·001 per cent. lead. The evidence obtained indicated that the deformation of polycrystalline copper by cold rolling took place by two mechanisms and that a double fibre texture, bearing a twinned relationship, was developed. The study of annealed copper strip showed that, with cold-rolling reductions of less than about 50 per cent. in thickness, the metal recrystallised without any preferred orientation. With reductions in excess of 50 per cent., two types of recrystallisation had been observed. In one type, the twin fibre textures of the cold-worked metal recrystallised independently to form two sets of crystals, each set having a preferred orientation corresponding to that of one or other of the twin fibre textures. In the other type, the twin fibre textures coalesced on annealing to form one set of crystals with a single preferred orientation. After very heavy reductions, of the order of 97 per cent., the recrystallisation on annealing was exclusively of the latter type; but, with lesser reductions, both types of recrystallisation had been shown to occur simultaneously on annealing.

The first speaker in the discussion, Dr. Bruce Chalmers, speaking of annealing effects upon grain growth, said that it was striking to note the manner in which crystals were related in their orientation, although not identically, with the orientation of the fibre structure. Such a relationship had been found by workers in iron. The next speaker, Dr. L. Frommer, stressed the point that whereas, in the case of copper, two different types of orientation occurred in the rolled material, nothing of a similar character had been revealed in aluminium alloys. Dr. H. O'Neill, who spoke next, asked the authors why they had not commenced with a hot-rolled material instead of a cold-rolled one. The last speaker, Dr. Wood, stated that he had long been of the opinion that X-ray work should be combined with metallurgical examination and mechanical testing. He was pleased to see that, in the present paper, such a combination had been made. In a brief reply, Dr. T. Ll. Richards said, with regard to Dr. Frommer's comments on points of difference between copper and aluminium, that each alloy or metal must be examined on its merits. In point of fact, aluminium did not have the same cold-rolled texture as copper; consequently, one would not expect it to crystallise in quite the same manner. Dr. O'Neill had asked why the authors had experimented with the metal chosen, namely, a fully-annealed material of a particular grain size and with random orientation; this metal had been taken as representing the simplest material upon which to commence operations. Hot-rolled material was often in a semi-hard state, and it was difficult to ascertain its precise condition.

AGEING OF A COPPER-ALUMINIUM ALLOY.

The third and last paper considered dealt with "The Ageing of High-Purity 4 Per cent. Copper-Aluminium Alloy," and was by Dr. M. L. V. Gayler and Mr. R. Parkhouse. In presenting the paper, Dr. Gayler stated that experimental evidence, based on the microscopic analysis and on measurements of the Brinell hardness of a 4-per cent. copper-aluminium alloy, during ageing for prolonged periods at temperatures lying between 0 deg. C. and the quenching temperature, had fully confirmed the theory of ageing put forward by her in 1937. Age-hardening took place in two stages, each of which presented a maximum on the hardness-temperature curves. Up to the time of attaining the first maximum on the hardness curves, submicroscopic changes occurred within the grains, but, after this state had been reached and before the increase in hardness due to the second stage of ageing set in, changes occurred both within the grains and in the grain boundaries. The second stage of ageing was accompanied by visible precipitation within the grains, but no precipitate could be detected with any certainty in the grain boundaries until just after maximum hardness had been attained. This fact was contrary to what had been generally accepted up till the present.

The only speaker in the discussion, Dr. C. Sykes, said that the contribution contained certain fresh evidence in support of the theory, put forward some years ago, that age-hardening in the copper-aluminium alloys involved two processes, usually termed the first and second stages of precipitation. At one time, the experimental basis for this theory consisted primarily of hardness-time curves, and he had been very sceptical of their interpretation, as "scatter" in the hardness was relatively high. This criticism, however, could not be made of the curves in the present paper; they all had the same general shape and the scatter was very small indeed. The paper also showed that certain definite structures could be associated with the different parts of the hardness-time curve, and this correlation had been made more certain as the result of X-ray work carried out by Preston and Gayler. As to the general application of the authors' theory to other systems, a certain amount of caution was necessary, because the aluminium-copper system was likely to be found to be a special case.

THE INDUSTRIAL HISTORY OF SWEDEN.

By ENGINEER-CAPTAIN EDGAR C. SMITH, O.B.E., R.N.

AT no time in our history have the map and geography of Scandinavia been studied with such close interest as they have been recently. In these circumstances, it may not be inappropriate to recall some of the history of the industries in the greatest of the three Scandinavian countries, and some of the pioneers who have contributed to industrial progress in Sweden. For centuries, through interchange of commerce, through the arts and sciences, and especially through ties of kinship, the bonds between Sweden and Great Britain have been close and intimate. Gothenburg, indeed, at one time, with its families of Carnegies, Chalmers, Macleans, and others, was almost a British colony. Sweden has seen a full share of war. It was Gustavus Adolphus, "the Lion of the North," who, as the inscription on his monument at Breitenfeld says, "saved religious liberty for the world."

The area of Sweden is 173,000 square miles, nearly twice as great as that of Great Britain and Northern Ireland. The total population is about 6,230,000, giving an average of 35 persons to the square mile, as against the British average of 490 persons. Of the total area, 60 per cent. is forest, 12 per cent. agricultural land, and the remaining 28 per cent. water and mountainous country. In 1930, 35 per cent. of the population was dependent on agriculture, 32 per cent. on industry, mining and handicrafts, and 16 per cent. on trade and transport. There are few deposits of coal, but the available water power has been estimated at 7,000,000 kW, of which about 2,000,000 kW has been developed. As all the world now knows, there are practically inexhaustible supplies of rich iron ore; but Sweden also possesses considerable quantities of copper, zinc, lead, arsenic, silver and gold.

The character of the Swedish people has never been more clearly sketched than by James Nasmyth, who, in his entertaining autobiography, described his visits to Stockholm, Uppsala, the Dannemora Mine at Osterby, and his journey through the Göta Canal in 1843. "With all their virtues," he said, "the Swedes are a most self-helping people. They are hard-working and honest, true and straightforward. In matters of commerce they are men of their word. They are clear-headed, honest-minded, and keen in their desire for knowledge. Their natural simple common sense enables them to clear away all parasitical and traditional rubbish from their minds, and to stand before us as men of the highest excellence."

To Swedish historians, the period 1719 to 1772 is known as "the Era of Liberty." Its beginning was marked by the curbing of the autocratic power of the reigning sovereign and the establishment of a parliamentary system. Among the great men who lived in that period were Linnæus, Swedenborg, Christofer Polhammar, better known as Polhem, and Marten Triewald. This sketch, therefore, may well begin with this era. In vol. VII of the *Transactions of the Newcomen Society* are two papers by Swedish authors. The first was by Mr. J. G. A. Rhodin and is entitled "Christofer Polhammar, ennobled Polhem: The Archimedes of the North (1661-1751)." The second, by Mr. A. Waerland, dealt with "Marten Triewald and the First Steam Engine in Sweden." Polhem was born in December, 1661. He studied science at Uppsala University, and then was appointed mining engineer at Stora Kopparberget, the famous copper mine at Falun, the oldest industrial undertaking in the country and "the cradle of Swedish industry." Here he introduced many improvements in mining and the working of metals, his work leading him to be made "Assessor" to the Board of Trade. From the centre of Sweden he was called to the south to construct the gates for the large dry docks at Karlskrona and to make the Trollhättan Falls passable for ships, but this latter work had to be dropped, only to be taken up again when Polhem was 88 years of age. Five years before he died, he finished what he called his "patriotic testament," and in this is to be found his description of rolling mills for iron, a thing then unknown in this country. In 1911, the Swedish Union of Engineers, to celebrate the 250th anniversary of Polhem's birth, published a volume devoted to his life and his work as a craftsman, in mechanics and as a civil engineer.

Triewald had a shorter life than Polhem, being born in 1691 and dying in 1747; but through his scientific attainments and his knowledge of the Newcomen engine, he became almost as famous. Swedish iron had been used in England in the Seventeenth Century, much to the chagrin of British manufacturers, who sued Charles II to forbid its importation. It was the trade in Swedish iron which apparently brought young Triewald to England, where he spent the ten years from 1716 to 1726. In London, he became acquainted with Desaguliers, Newton and other scientific men. At Newcastle, he built a Newcomen engine for Mr. Ridley, and, when he returned to his native country, he took with him a large collection of scientific instruments, which is now preserved at Lund University. His lectures in 1728-29, it is said, filled the large hall of the House of Lords in Stockholm. At Dannemora, too, he erected a Newcomen engine, and in 1734 published his "Description of the Fire-and-Air Machine at the Dannemora Mines"—the first publication devoted solely to the steam engine. Triewald was a fellow of the Royal Society of London from 1731 onwards, and it was through his efforts, combined with those of Linnæus, of Claude Grill (1704-67), and one or two others, that the Royal Academy of Science at Stockholm was founded in 1739. A Society of Science had been founded in Uppsala some twenty years before, but the association which has played the greatest part in Swedish industry is "The Association of Swedish Ironmasters," Jernkontoret, the official rules for which were sanctioned by King Frederik I in 1747. The history of Jernkontoret was the subject of a paper by Mr. E. Kinander to the Iron and Steel Institute in 1926. Nothing concerning the iron and steel industry is outside the scope of the activities of the Association, and it has done and is doing

valuable work in research and technical education. The increasing interest in science in Sweden during the Eighteenth Century was also shown by the foundation of the Royal Man-of-War Society of Karlskrona in 1771, of the Royal Physiographical Society of Lund in 1772, and the Royal Society of Sciences and Literature in Gothenburg in 1773. The Man-of-War Society was founded when Admiral F. H. Chapman (1721-1808) was chief constructor of the Swedish Navy.

Owing to her geographical position, the sparseness of her population and the distress caused by many wars, Sweden was one of the last of the Western nations to be affected by the revival of mathematical studies in the Sixteenth and Seventeenth Centuries. At the beginning of the Eighteenth Century, she counted among her physicists Anders Celsius (1701-40), of thermometer fame, and Samuel Klingenstierna (1698-1785), known especially for his work in optics; but it was in chemistry that Swedish men of science excelled. Progress in mining, metallurgy, assaying and chemical discovery went hand in hand. To illustrate the work done in the course of the Eighteenth Century, the following brief notes are given of some of the outstanding men. These are given in chronological order, according to the year of birth. Georg Brandt (1694-1768) was a Councillor of Mines and Superintendent of the Mining Board. He made the first accurate experiments on the chemical nature of arsenic, and in 1733 distinguished cobalt as a metal. Anton von Swab (1702-68), who was born at Falun, was an eminent inspector of mines; he discovered a method for extracting zinc and was a pioneer in the use of the blow-pipe. Johan Wallerius (1709-1785), professor of metallurgy and chemistry at Uppsala, wrote one of the first systematic treatises on mineralogy. Henrik Scheffer (1710-59) was known for his many analyses of metals and plants. The name of Sven Rinman (1720-92) is one of the most honoured among Swedish metallurgists. He held high offices in the iron and steel industry and, financed by Jernkontoret, he published three important works: Firstly, "On the Manufacture of Heavier Iron and Steel Goods" (1772); secondly, a "History of Iron" (1777-1782); and, thirdly, "A Dictionary of Mining and Metallurgy" (1788-89). In 1917, Jernkontoret instituted a gold medal for research within the Swedish iron industry, and this medal bears the image of Rinman. A short-lived contemporary of Rinman's was Axel Cronstedt (1732-65), the mining official who first obtained nickel from "kupfernickel." Next to these came Torbern Bergmann (1735-84) and Karl Scheele (1742-86), the former a professor at Uppsala and the latter an apothecary who was "at once the Priestley and the Lavoisier of Sweden." Bergmann it has been said, was the first to perform chemical analysis systematically. He was a pioneer in crystallography and mineralogy and added much to the chemistry of iron and steel. From the investigations of both Bergmann and Scheele flowed an immense number of discoveries useful to Swedish industry. Swedish mining was further indebted to the surveys of Gustaf Hermelin (1744-1820), who published twenty-six charts of Sweden; to the researches of Johan Gahn (1745-1818), an assessor of the College of Mines, who added manganese to the list of elements; the travels and reports of the Inspector of Mines, B. L. Geyer (1758-1815), and to the work of the metallurgist, Nils Sefström (1787-1845), who discovered vanadium in 1830. The greatest of all Swedish chemists was Jons Jakob Berzelius (1779-1848), one of the founders of modern chemistry.

The advancement of the arts and manufactures in Sweden in the Eighteenth Century was also furthered by various public men and administrators. One of these was Jonas Alström (1685-1761), later ennobled under the name of Alströmer. In his travels as a shipowner he studied, "with burning desire," ways of introducing into his native land the methods and manufactures of England. Smuggling home not only foreign tools and raw material, but even British workmen, at his birthplace, Alingsås, near Gothenburg, he set up spinning wheels, stocking factories and tobacco works. Alingsås became a model factory with an industrial school. As the "father of Swedish arts and crafts," he paved the way for future developments. Later, Sweden owed much to the Scotsman, Thomas Lewis, who died in Sweden in 1783, at about 36 years of age, and to the Englishman, Samuel Owen (1774-1854). Their story is told in a paper in volume VIII of the *Transactions of the Newcomen Society*, by Mr. Carl Sahlin, who has done for Swedish industrial history what the late Oskar von Miller did for German engineering history. Lewis carried to Sweden the methods of the famous Carron Ironworks and with his countryman, Robert Finlay, established the Bergsund Works in Stockholm, which became the first important engineering works in Sweden. It was in these works that the first Swedish-built, Watt steam engine was constructed. The drawings of this engine were prepared by Owen, who had been a pattern maker at Boulton and Watt's Works at Soho, and had served with Fenton, Murray and Wood at Leeds. In 1804, the Swedish nobleman, Baron Edelcrantz (1754-1821), visited England to purchase four steam engines. Three of these were made in Leeds, and Owen was sent to erect and start them. From 1806 onwards, Sweden became his home. He founded an engineering works at Kungsholmen, and one of the large beam engines he built there for draining a coal mine, after working from 1832 to 1903, has now passed to the Technical Museum in Stockholm. Sweden was indebted to Owen, moreover, not only for the impetus he gave to mechanical engineering; with him went Methodist preachers and workmen, whose influence led to a religious awakening and the temperance movement. The trade unions, the labour movement, co-operative societies, and the social legislation improvements of Sweden can be traced back to Owen, the English engine builder. His adopted country was not slow to show its gratitude. He received pensions from both the Riksdag and Jernkontoret, he was elected a member of the Royal Academy of Science, and, after his death in Stockholm on February 15, 1854, a commemorative medal of him was struck.

Without attempting to trace all the developments of the Nineteenth Century which raised Sweden to a prominent place among industrial nations, a few of the outstanding events and men may be touched upon. In 1830, Gustaf Ekman introduced into the Swedish iron industry the Lancashire refining hearth, worked with charcoal, which he had studied at Ulverston. This furnace replaced the Walloon furnace, introduced into Sweden in the first quarter of the Seventeenth Century by Louis de Geer (1587-1652), of Flanders. In 1832 the Göta Canal, on which Telford reported in 1808, was completed giving a waterway 10 ft. deep from Gothenburg to Stockholm by way of Lakes Vanern and Vattern. One of the engineers employed on this canal was Nils Ericsson (1802-70), brother of John Ericsson. To him, in 1856, fell the task of constructing the first railways in Sweden. In 1858, G. F. Göransson (1819-1900), founder of the Sandviken Works, introduced his valuable improvements in the Bessemer process; in 1859, Alfred Nobel (1833-96) returned to Sweden from Russia and began his epoch-making work on explosives; in 1871, Carl Daniel Ekman (1845-1904)—whose grave is in a Kentish cemetery—made his first experiments on the bleaching of mechanical wood pulp at the Bergvek Works of the British firm, Messrs. I. Thomson, T. Bonar and Company; and, in 1875, Gustaf de Laval (1845-1913) founded the Klosterwerken Iron Works, whence came the cream separator and the de Laval steam turbine.

Electric power has been of capital importance to Sweden. The General Swedish Electric Company (A.S.E.A.) was founded in 1883, and with this company was associated Jonas Wennström (1855-93), one of the pioneers in three-phase electrical distribution. Another pioneer of this time was Fredrik Kjellin (1872-1910), who, in 1899, brought out his induction steel-melting furnace. These facts are but the dry bones of the romantic history of Swedish industry, a full record of which would have to include shipbuilding and marine engineering, textile development, the match-making industry, etc., and the names of Welin, Ljungström, Brinell, Nordenfelt, Wingquist, Dalén, and many others.

Finally, a word or two may be said about the iron-ore industry of Sweden, and more especially of the great mines in the North. Here, in a district in which two hundred years ago Linnæus botanised and Celsius assisted the French men of science to measure an arc of the meridian, and which was peopled only by Laplanders with their herds of reindeer, are now vast undertakings, and a playground for the tourist. The exceedingly rich iron-ore fields of Norrland, which the State shares with the Grängeberg-Oxelösund Company, cover an area of more than 3,000 square miles, and estimates of the deposits run to astronomical figures. Here, too, is but another link between Swedish and British enterprise. In the March number of *The Anglo-Swedish Review* is an article based on the researches of Mr. Carl Sahlin. It is entitled "Altappen, the Northernmost Rolling Mill in the World: A Chapter from British Industrial Pioneering in Sweden." In 1869, the Gällivare Properties were acquired by Giles Loder and his son, Robert. Small iron works had been previously in operation at Luleå, but were dormant. The idea of the Loders was to bring semi-finished iron from thirty miles up-country to Luleå and put it through rolling mills. In 1871, they brought a group of barren rocky islands, six miles south of Luleå, and there set up a rolling mill and a saw mill, driven by steam engines. A foundry, a smithy and an engineering works were erected, and houses and a school built. In soil brought by ships coming north in ballast, the Loders made pastures and grew flowers, fruit, vegetables and shrubs. It was a model community. In 1890, the Altappen rolling mill was burnt down, and there was no economic justification for rebuilding it. Both ore and semi-finished iron had been transported by reindeer sledges, but, in 1889, a British company built a railway from Luleå to Boden. This was immediately acquired by the State, which, by 1894, had extended it to Gällivare, and, by 1903, to Kiruna and to the Norwegian frontier. The year 1903 also saw the foundation in Norway of the port of Narvik. The length of line in Sweden is about 250 miles; its extension in Norway about 25 miles. The line is now joined to the trunk lines of Sweden and, by a branch from Gällivare, the great hydro-electric station at Porjus can be reached. In 1937, Sweden produced nearly 15,000,000 tons of iron ore, most of which was mined in Norrland. Much of it went to Germany, which, without this ore, could never have re-armed as she has done. In 1938, the world production of steel declined about 21 per cent., as compared with 1937, but the German production increased by about 14 per cent. It is not surprising that a nation thinking only of military conquest should set covetous eyes on the Swedish ore fields.

THE AMERICAN SOCIETY FOR TESTING MATERIALS.

THE forty-third annual meeting of the American Society for Testing Materials is to be held at Chalfonte-Haddon Hall, Atlantic City, New Jersey, U.S.A., from Monday, June 24, to Friday, June 28. The whole of the first day will be devoted to committee meetings and the opening session will commence at 10 a.m. on Tuesday, June 25, when Mr. H. H. Morgan will deliver his presidential address. Twenty-two separate sessions for the presentation and discussion of technical papers and reports are to be held. Symposia have been arranged on "The Tools of Analytical Chemistry"; the "Significance of the Tensile Test in Relation to Design"; "Spectrochemical Analysis"; "Radiographic Analysis"; and "Problems in the Classification of Natural Waters for Industrial Use." Other papers will deal with methods of testing; corrosion; the properties of, and tests for, cement and concrete; the testing of non-ferrous metals; the properties of plastics, electrical insulating materials and rubber; the creep testing of steel; and tests of cast iron and of petroleum products, road materials and soils.

The symposium on tools of analytical chemistry has been arranged in co-operation with the American Chemical Society, and, among the subjects to be discussed are volumetric methods and amperometric titrations; electronic circuits applied to analytical chemical processes; theory and practice in the control of *p*H using a glass electrode; and microchemistry. The symposium on the tensile test, which is held in collaboration with the American Society of Mechanical Engineers and the American Institute of Physics, will embrace three papers, namely, "The Tension Test," by Professor C. W. MacGregor; "The Strength

Features of the Tension Test," by Professor F. B. Seely; and "The Ductility Features of the Tension Test," by Mr. H. W. Gillett. The symposium on spectrochemical analysis and that on radiographic testing, it is anticipated, will bring together leading American authorities in these two branches of science. The object of the symposium on the classification of natural waters is to secure uniformity in the reporting of figures for water analysis.

Among the papers dealing with methods of mechanical testing are two which are concerned with the influence of speed in testing. One of these contains an account of an investigation on the effect of the rate of strain on the results in tensile tests on metals; the other paper relates to the effect of speed on yield-point values. In the non ferrous-metal section of the meeting, contributions on the creep of aluminium subjected to bending at normal temperatures; on proportional-limit tests on copper alloys; and on internal hydraulic bursting tests of lead cable sheathing, will be presented.

THE LATE MR. W. V. GRAHAM.

WE regret to record the death, on May 22, of Mr. William Vaux Graham, M.Inst.C.E., at the age of 80 years. He was well known as a consultant on water supply and the utilisation of water power, and was chairman of the Association of Consulting Engineers in 1921-22. Mr. Graham commenced his career in 1876 as a pupil in the office of the late Mr. R. W. Peregrine Birch, M.I.Mech.E., being engaged in general engineering, and more particularly on water-supply and drainage work. On the completion of a three years' pupilage, he was retained on Mr. Birch's staff, becoming his principal assistant in 1885 and continuing in this position until 1896, when Mr. Birch died. Mr. Graham then succeeded to the practice. Among his clients were the British Aluminium Company, Limited, for whom he designed the water-power plant at the Falls of Foyers. He acted as engineer to the Sutton District Water Company, the East Grinstead Water Company, and the Great Marlow Water Company, Limited, and was consultant to the Epsom Urban District Council for the construction of their water works. Mr. Graham, who was elected a member of the Institution of Civil Engineers in 1896, and of the Institution of Mechanical Engineers in 1900, was also an associate of the Chartered Surveyors' Institution, and a Fellow of the Royal Meteorological Society, and of the Society of Antiquaries.

THE LATE MR. J. F. I. THOMAS, O.B.E.

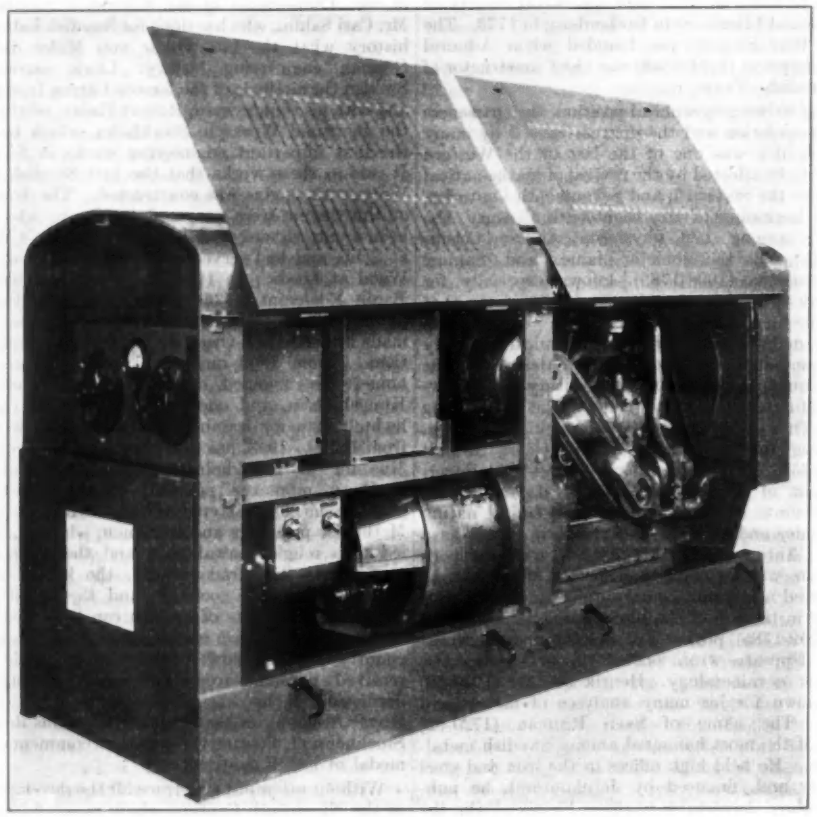
MR. JOHN FREDERICK IVOR THOMAS, of whose death we have learned with regret, had an unusually varied engineering career. He was born on September 13, 1871, and, on leaving the North-Eastern Counties School at Barnard Castle in 1887, entered the Bridge Department of the Darlington Wagon and Engineering Company, where he remained for two years. He then went as an apprentice to the marine-engine works of Messrs. Wigham Richardson and Company at Walker-on-Tyne, where he served for three years. In May, 1893, he went to sea as fourth engineer of the S.S. Holkar, but, in October of the same year, he left the sea to take up an appointment as assistant in the consulting office of the late Professor A. B. W. Kennedy, in Westminster. His particular connection was with the generating station of the Battersea Corporation, for which he was Messrs. Kennedy and Jenkin's resident engineer.

During his apprenticeship on the Tyne, Mr. Thomas attended classes at Armstrong College, Newcastle-on-Tyne, and he subsequently continued his technical education in London at University College and King's College. On the completion of the Battersea contract, he was employed for some eight months on work in connection with the London County Council's electric-tramways power station at Greenwich; but, in September, 1902, he left Messrs. Kennedy and Jenkin to join the consulting firm of Messrs. Mordey and Dawbarn, and accompanied the partners to South Africa to assist in preparing a scheme for electric lighting and tramways for the Johannesburg municipality. While there, he also reported on a similar project for the Pretoria Town Council, and on a scheme for the electrification of the Central South African Railway. On returning to England in May, 1903, he was given charge of the design work for the Johannesburg station and, in the following year, went again to South Africa to superintend its erection and completion. For a while he continued to represent Messrs. Mordey and Dawbarn in South Africa, but, in 1905, he was appointed general manager of the Johannesburg Gas, Electricity Supply and Tramway Department, remaining in that position for three years before returning again to England.

In 1910, Mr. Thomas joined the staff of Messrs. Vickers, Limited, as their electrical inspector at Sheffield, and soon afterwards was sent by them to Winnipeg to supervise the erection of a 20,000-kW water-power plant. He remained in Canada as representative of Messrs. Vickers, Limited, until November, 1915, when he obtained leave of absence to join the inspection staff at Woolwich Arsenal. Actually, however, he was appointed almost immediately to the inspection department set up in the United States by the Ministry of Munitions, and was in charge, at various times, of the inspection districts centred on Cincinnati, Cleveland, Chicago, Duluth, St. Louis and Buffalo. For these services he received the O.B.E. On the conclusion of hostilities, he returned to Messrs. Vickers, Limited, and from 1919 to 1931 was manager of their general engineering department in London. In 1931, he was appointed managing director of Messrs. British Jeffrey-Diamond, Limited, Stennard Works, Wakefield, and was still holding this position at the time of his death, on May 25. He was also a director of the British Spiro Turbine Company, Limited. He was elected an associate-member of the Institution of Civil Engineers in 1896, and of the Institution of Mechanical Engineers in 1900, being transferred to the grade of member in the two institutions, in 1918 and 1904, respectively.

DIESEL-ENGINE DRIVEN WELDING SET.

MESSRS. THE LINCOLN ELECTRIC COMPANY, LIMITED.



DIESEL-ENGINE DRIVEN WELDING SET.

THE welding set illustrated in the accompanying figure has been recently introduced by Messrs. The Lincoln Electric Company, Limited, Welwyn Garden City, Herts. The power unit is a Hercules Diesel engine of the four-cylinder type, the cylinder bore being 4 in. and the piston stroke 4½ in. The engine develops 47 brake horse-power at 1,500 r.p.m., and the output of the welder on continuous rating is 300 amperes. One of the special features of the set is that the Diesel engine is started by means of a small petrol engine. The latter engine is mounted above the end of the generator with the crankshaft at right-angles to that of the main engine. The drive is transmitted through a clutch, the clutch shaft being extended through the casing and carrying a multiple Vee-belt pulley. The clutch casing and pulley can be seen in the illustration, and it will be noticed that the belt drive is taken to a second pulley at approximately the level of the base of the cylinders. This second pulley is mounted on the worm shaft of a right-angled worm-and-wheel reduction gearing, the worm wheel being mounted on the Diesel-engine starter shaft. The petrol engine is started by a hand crank. Starting in cold weather is facilitated by the fact that the cooling system of the petrol engine is connected with that of the main engine, so that the latter can be warmed up by running the petrol engine for a short time and allowing the heated water to circulate through the Diesel cooling system.

The main engine has the cylinders cast *en bloc* with a removable head. The crankshaft is a heat-treated drop forging, drilled for the forced-feed oiling system. The journals are Tocco-hardened, and the shaft is dynamically balanced. The connecting rods are nickel-chrome-molybdenum steel drop forgings of I section, and are heat treated. The small ends are phosphor-bronze bushed, and the big-end bearings are fitted with steel shields lined with Hi-lead bronze. The main bearings are of the same type as the big-end bearings. The pistons are of heat-treated aluminium alloy with fully-floating gudgeon pins, and are fitted with four compression rings, one oil ring above the gudgeon pin, and a wiper ring below. The drive to the camshaft is by helical gearing. Overhead valves are employed, the exhaust valves being of silchrome steel. Lubrication is by pressure to the main bearings, the big and small ends, and the rocker-arm bearings and accessory shafts. An oil purifier is built into the engine. The cooling water is pump-circulated.

The generator has a current range up to 400 amperes for welding duty with a maximum pressure of 40 volts at the arc. The output for welding duty is 16 kW, which is stated to be ample for operating electrodes up to $\frac{5}{16}$ in. or $\frac{3}{8}$ in. in diameter, and to secure economical welding costs. The generator is a standard Lincoln S.A.E. 300 "shield-arc" model, equipped with self-indicating dual continuous control, polarity-reversing switch and voltammeter, and is fitted with a separate exciter to give ample reserve of power. The control makes possible the independent adjustment of both voltage and current so that the correct type of arc and the correct heat are immediately available for all welding applications. The frame of the generator is attached directly to the housing of the Diesel engine. The generator is driven from the engine through a flexible coupling. The entire unit is mounted on a substantial channel frame. The fuel consumption is 1·5 gallons per hour at full-load operation, the corresponding fuel consumption of a petrol engine being about 2·75 gallons per hour.

IMPROVEMENT OF WORKS-SUPPLY POWER FACTOR.

THE problems that arise in giving an electricity supply to a large works from the public mains are illustrated by an installation which has recently been carried out in a modern factory for the production of radio and television components, by Messrs. Crompton Parkinson, Limited, Bush House, London, W.C.2. The necessary three-phase energy for operating this factory is obtained from the public mains at 6·6 kV and a frequency of 50 cycles, the incoming feeders being controlled by metal-clad compound-filled switchgear with a rupturing capacity of 200,000 kVA. This equipment, which has been type tested, has vertical isolation and is mechanically interlocked to ensure safety in operation and during overhaul. The incoming cables can be earthed while internal adjustment is taking place. From this switchgear a supply is given to a ring main, which, in turn, is connected to three substations through Crompton Parkinson ring main units. Each of the substations is equipped with two 500-kVA transformers, which were constructed by Messrs. The British Electric Transformer Company, Limited, Hayes, Middlesex, and on the secondary side provide a supply for works purposes at a pressure of 400 volts. The output of these transformers is controlled by Crompton metal-clad industrial-type switchgear with a rapturing capacity of 25,000 kVA and a current-carrying capacity of 800 amperes. These switches are connected to low-tension 'bus bars, from which a supply is taken through similar switches with current-carrying capacities ranging from 600 amperes to 800 amperes to the various works feeders.

In accordance with modern practice, the majority of the machine tools employed in the factory have been fitted with individual drives and many hundreds of squirrel-cage induction motors, with outputs varying from 1 h.p. to 10 h.p., have been installed for the purpose. In most cases, standard foot-mounted Crompton Parkinson motors have been adopted and employed in conjunction with Vee-rope drives. A disadvantage of units using a large number of small machines is, of course, the low power factor that results. In order to comply with the requirements of the supply authority, it was therefore necessary to raise the power factor to 0·85 lagging, and, in view of the load diversity and the number of small driving units, to employ synchronous condensers with automatic control for the purpose. In order, however, to obtain the required power factor at the point of metering on the supply authority's high-tension board, a figure slightly better than this had to be obtained in each of the three substations. For this purpose, a 250-kVA synchronous condenser, controlled by a stator switch on the feeder board mentioned above, has been provided, and is interlocked so that the condenser cannot be started unless the liquid starter is in the correct position. On the other hand, the motors supplied from the third substation are of the auto-synchronous type, so that a synchronous condenser is not required.

In order to obviate an undesirable leading power factor under any condition of loading, automatic control is provided on the two synchronous machines by Whipp and Bourne regulators. These consist of a wattmeter element, which is in a neutral position when the power factor is at the required figure. If, owing to a change in load, the value varies, a torque is exerted by the element which causes auxiliary circuits to be closed and the output of the condenser to be adjusted by the shunt regulator, so that the correct value of the power factor is restored. In this way, any predetermined value of power factor between 0·6 lagging and unity can be automatically obtained. The total corrective capacity provided by the synchronous plant is sufficient to maintain the required power factor under maximum load conditions. Under average conditions, therefore, a small margin is available.

The most recent addition to the load supplied from the third substation is an 80-h.p. air compressor. To assist in maintaining the power factor, this is driven by an auto-synchronous motor with a leading power factor of 0·8. The secondary winding of this motor is designed to give particularly good performance at starting, and high efficiency during running. The control gear consists of a combined rotor and stator starter, such as might be used on a slip-ring induction motor of equivalent rating. In addition, a control pedestal is provided. This carries an excitation regulator and a moving-coil ammeter, so that an indication of the degree of correction may be obtained.

STAINLESS-STEEL RAILWAY COACHES.—It is stated in the *Welding Journal* that an order for 28 coaches, built of stainless steel, has been placed with the United States firm, Messrs. The E. G. Budd Company, by the Portuguese National Railways. The design is similar to that of coaches built for American Railways.

LABOUR NOTES.

EMPLOYERS' organisations and the trade unions of which their workers are members are co-operating with the Government in the national effort to increase and expedite the production of war munitions. The principal clause in the new Defence Act is in the following terms:—"The powers conferred on His Majesty by the Emergency Powers (Defence) Act, 1939, shall, notwithstanding anything in that Act, include power by Order in Council to make such defence regulations making provision for requiring persons to place themselves, their services and their property at the disposal of His Majesty as appear to him to be necessary or expedient for securing the public safety, the defence of the realm, the maintenance of public order, or the efficient prosecution of any war in which His Majesty may be engaged, or for maintaining supplies or services essential to the life of the community." The new Act extends the duration of the 1939 Act from one to two years.

In introducing the measure in the House of Commons, Mr. Attlee explained that, under the Act, the Minister of Labour would have power to direct any person to perform any service required. Labour supply centres would be set up and a bold and comprehensive training scheme started. In certain cases, there would be compulsory notification of men who were stood off or on short time. The essential thing was that there should be no waste of skilled labour. On the subject of control of property, he said that some establishments—particularly those engaged on munitions—would be taken over by the Government. Wages and profits would be under Government control, and Excess Profits Tax would be at the rate of 100 per cent. There might be occasions on which firms would have to be closed down; some destruction of property might also be necessary.

Control of the finance of the country, Mr. Attlee continued, might be exercised centrally or through Regional Commissioners if necessary. The banks would be controlled and operate under Government orders. There would be full control of building operations. The Minister of Labour would work in the closest co-operation with the trade unions and the employers' organisations. If agreements in industry were set aside, for the time being, there would be a provision that if they were not restored by an employer at the end of the war he would be ineligible for the Government contract list.

The General Council of the Trades Union Congress met Mr. Bevin, the Minister of Labour and National Service, and the full executive of the British Employers' Confederation at the Ministry of Labour on Wednesday last week. An official statement issued at the close of the meeting announced that the following resolution had been passed:—"That this Joint Advisory Council representative of the British Employers' Confederation and the T.U.C. General Council, having heard the Minister of Labour on behalf of the Government, and recognising the gravity of the situation, resolves wholeheartedly to co-operate in the steps necessary to secure the protection of the country and an Allied victory." It was resolved to appoint a consultative committee to advise the Minister of Labour on matters arising out of the legislation passed by Parliament.

Mr. Bevin's two main objects are stated to be to utilise every available man and woman in the factories and to avoid waste of labour and unequal conditions in the workshops. It is hoped to arrange for the better distribution of skilled labour and to draw up a training scheme which will render labour more mobile and fitter to cope with sudden demands. The aim will be to keep every factory engaged on war work fully staffed.

The following resolution was adopted at a conference in London, on Saturday last, attended by the executive councils of the trade unions affiliated to the Trades Union Congress:—"This conference having received a report of the discussions between the General Council and the Government realises the gravity of the dangers inherent in the present situation. The conference endorses the action of the General Council in giving its full support to the necessary measures that must be taken to protect our people against these dangers by organising the entire resources of the country and striving to the utmost to defeat the forces of aggression. The conference expresses its complete confidence in the General Council and their representatives on the consultative committee, appointed to advise the Ministry of Labour on all matters arising out of the Emergency Powers Defence Act and other legislation enacted by Parliament, in the fullest assurance of their determination to preserve the powers and functions of the trade unions and to ensure the maintenance of the hard-won liberties of the workers."

It was announced on Saturday last that Mr. Bevin, the Minister of Labour and National Service, has set up a Labour Supply Board of four directors with himself as chairman. The four directors are Mr. K. C. Appleyard (managing director of the Birtley Company), Mr. R. Coppock (secretary of the Building Trade Operatives), Mr. J. C. Little (ex-president of the Amalgamated Engineering Union) and Mr. A. D. Young, of the British Thomson-Houston Company. A local labour supply committee will be set up in each important area. These committees will work in close conjunction with the employment exchanges.

The executive council of the Amalgamated Engineering Union has informed members of the organisation that whenever they are called upon to work overtime they should respond as fully as possible. It is added that the extra payments provided for in existing agreements will be made.

Early last week, Mr. Herbert Morrison, the Minister of Supply, instructed all Royal Ordnance and contractors' works engaged on urgent Ministry of Supply contracts to work full time seven days a week until further notice. Most Royal Ordnance factories are now working two 12-hour shifts daily. The general response to the order to work over the week-end and as much overtime as possible was, it is officially stated, highly satisfactory.

At a conference in London last week, representatives of the Engineering and Allied Employers' National Federation, the Transport and General Workers' Union, the General and Municipal Workers' Union and the Amalgamated Engineering Union reached agreement on the subject of the wages to be paid to women who undertake war work, replacing men, in the engineering industry. The agreement lays down "the conditions of the extended employment of women brought temporarily into the engineering industry." The quoted words are of considerable importance as there are already large numbers of women regularly employed in the industry. The agreement provides that, for a probationary period of eight weeks, women shall be paid at the women's national schedule time rate and bonus. For the next 12 weeks the basic rate is to be increased by one-third of the difference between the women's schedule rate and that of the men they replace, and they will also receive one-third of the difference between the women's bonus and the men's bonus. After that, for a period of another 12 weeks, the basic rate for women is to be 75 per cent. of the men's rate, with 75 per cent. of the men's bonus added. Thereafter women who require no special supervision will receive the basic rate and the bonus applicable to men.

According to *The Ministry of Labour Gazette*, the number of insured persons between the ages of 16 and 64 recorded as unemployed in Great Britain and Northern Ireland at April 15 represented 6·7 per cent. of the total number of insured persons between the ages of 16 and 64 at July, 1939, as compared with 7·7 per cent. at March 11, 1940. At April 17, 1939, the percentage unemployed was 11·2. For persons insured under the general scheme, the corresponding percentages were 6·8 at April 15, as compared with 7·8 at March 11 and 11·5 at April 17, 1939. For persons within the agricultural scheme, the percentages were 4·4, 7·0 and 6·2, respectively.

At April 15, there were 840,027 persons on the registers of Employment Exchanges in Great Britain who were out of a situation. This was 125,640 less than at March 11 and 503,268 less than at April 17, 1939. There were registered as unemployed in Great Britain 90,182 persons who were on short time or otherwise temporarily suspended from work. This was 19,198 less than at March 11 and 148,547 less than at April 17, 1939. Of workers who normally seek a livelihood by means of jobs of short duration there were on the registers in Great Britain 42,486 unemployed persons. This was 3,680 less than at March 11 and 19,884 less than at April 17, 1939.

In the industries for which statistics are regularly compiled by the Ministry of Labour and National Service, the changes in rates of wages reported to have come into operation in April are estimated to have resulted in an increase of about 198,000*l.* in the weekly full-time wages of 1,600,000 workpeople and in a decrease of about 100*l.* in those of 3,500 workpeople. The latter, however, had received increases of greater amount in the earlier months of the year.

ROLLING EXPERIMENTS WITH SHIPS AND MODELS IN STILL WATER.*

By R. W. L. GAWN, R.C.N.C.

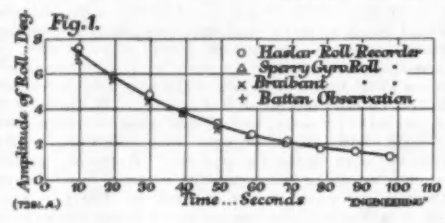
THE report of the Admiralty Committee of 1871 on "The designs upon which ships of war have recently been constructed" includes an account of experiments made under William Froude's directions on a model, $\frac{1}{24}$ full size, of H.M.S. Devastation, a large ironclad. The model was ballasted to give the correct centre of gravity to scale and the correct radius of gyration to represent the dynamical conditions of the ship. As a result of these investigations, Froude recommended the use of deep bilge keels, and was supported by the Committee. These tests are of historical interest as one of the first investigations into the usefulness of bilge keels to ascertain the damping effect in still water in a quantitative and accurate manner, and, as such, are of important relevance to the purpose of this paper. Bilge keels have been fitted from the earliest days of ironclads in H.M. Navy, but wooden sailing ships were constructed without bilge keels in the first half of the Nineteenth Century. William Froude was certainly one of the earliest if not the first advocate of their general use.

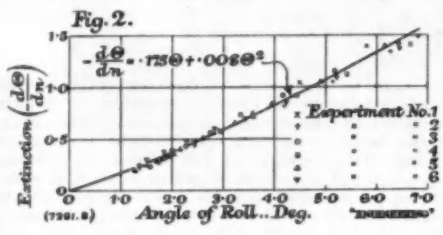
Although high authorities in naval architecture opposed bilge keels at the time of the Devastation trials, there does not seem to have been any question as to the validity of the application of the model results to ships. Rolling experiments were also made on the ship, and some of the still-water results are noted in Vol. 24 of the *Trans. I.N.A.*, page 174. The period of roll of the ship (13·52 seconds), as given in the paper referred to, is much greater than the corresponding period of the model experiments (11·4 seconds to 12 seconds). Curves of declining angles for H.M.S. Devastation, taken on four occasions from 1873 to 1875, and of her model, indicate that the extinction is greater in the ship at angles below 4 deg., with a tendency to be less at larger angles. Neither the diagram nor the text of the report gives any indication of the loading of the ship or model, or of the period and stability, so that definite conclusions cannot be drawn. Rolling experiments have been made on models and ships since Froude's time, but a scrutiny of the *Trans. I.N.A.* fails to reveal any investigation to determine the degree to which the model experiments can be relied upon to assess the rolling qualities of a ship. Reports from sea confirm the substantial accuracy of estimates from model experiments; Sir Stanley V. Goodall, in his paper last year on H.M.S. Ark Royal,† remarked that the rolling of the ship has generally not exceeded 5 deg. in the Bay of Biscay. From experiments in uniform waves with a model, it was inferred that, in a fresh gale of force 8, the ship would roll to a maximum angle of 2·2 deg. and to 7·3 deg. in a strong gale of force 9.

Early in 1938, the Director of Naval Construction arranged for experiments on a ship then completing with the object of comparing her rolling qualities in still water with those of the model, previously tested. The trial had a practical objective, namely, to check whether the improvements in anti-rolling effect of different arrangements of keel, obtained with models of ships of current building programmes, would be borne out on the full scale. The investigation yielded some unexpected results and led to tests on two models of older ships, the rolling qualities of which were known from trials in still water. The results have been included in this paper.

It was decided that the vessel selected for first trial should be a destroyer, since the difficulty in working up a roll would be less than in a larger ship. H.M.S. Nubian, a Tribal-class destroyer of the 1935 programme, was chosen, and the test was carried out in a basin at H.M. Dockyard, Portsmouth. It was decided to work up the roll by men running from side to side, and, to obtain as large a travel for the men as possible, wooden platforms were erected on the ship to give a wide space free from obstructions. The rolling party was formed by 117 men, and the maximum roll was about 7½ deg. off the vertical. When the maximum amplitude was obtained, the party remained stationary in assigned positions and the angle and period of roll were automatically recorded on two short-period pendulums and a gyro roll recorder (long period), and also by batten observations. The pendulums were located approximately at the centre of gravity of the ship. One of the two former instruments had been made many years previously under R. E. Froude's directions and used on ship trials, but modified to give an enlarged scale of reading, namely, ½ in. to 1 deg. The other short-period pendulum was of proprietary make, known as the Braibant M.A.R. Recorder. Results obtained by the various pendulums showed very good agreement among themselves and with the batten observations, as is evidenced by Fig. 1, herewith. Six separate rolling trials were made in order to obtain a good average extinction curve. The values of extinction derived from these experiments are shown in Fig. 2, on this page. A carefully conducted inclining experiment was carried out in conjunction with the rolling trial, to obtain the metacentric height and position of centre of gravity. It was, unfortunately, necessary for the trials to be made with oil fuel in the ship. To minimise the complications arising from free surface of the oil, the tanks were 97 per cent. full, which was as large a stowage as was considered safe having regard to possible expansion with temperature rise. Calculations show that the fluidity of the oil fuel has a negligible effect on statical stability for inclinations in excess of 2 deg. Typical rolling diagrams are reproduced in Figs. 3, 4 and 5, on the opposite page. Fig. 3 is the diagram obtained from the ship, using a Haslar Recorder, Mark III. Figs. 4 and 5, respectively, show the results of tests with a paraffin-wax model with all appendages, propellers and bilge keels, and without the bilge keels.

The rolling tests had covered a short range of period and stability to include the design qualities. The model was made in paraffin wax, $\frac{1}{24}$ full size, and the





bilge keels were of brass plate. Apart from minor improvements of the rolling platform and apparatus, the method employed was as described by Mr. M. P. Payne before this Institution in 1924.* The model was moored at 45 deg. across the tank near the mid-length by single cords led horizontally from bow and stern over fixed pulleys, each cord carrying a 5-lb. weight at the free end. The cord was attached to the model close to the water-line. The recording apparatus was secured to the stationary experiment carriage, which was arranged in position over the model. The roll was worked up by hand, care being taken to avoid giving to the model motion of any other description. The results indicated that the rolling extinction, expressed as loss of amplitude per swing

$$\left(-\frac{d\Theta}{dn} \text{ in the usual nomenclature}\right)$$

was less than that of the ship. To obtain a comparison with the ship it was found necessary to extrapolate the model results, since the condition differed from that corresponding to the ship trial as regards displacement and stability. Further rolling experiments were accordingly arranged with the model, which was ballasted to represent the ship to linear scale as regards draught forward and aft, position of centre of gravity, and radius of gyration. The earlier tests were made with the model held over at 20 deg., but in the later experiments the model was held over to the maximum angle built up in the Nubian still-water rolling trials, namely, 7½ deg. These more truly comparative experiments still revealed smaller rolling extinction compared with the ship. No measurable difference was found in the extinction curve or rolling period over the corresponding range of amplitude, whether the angle of release was 7½ deg. or 20 deg.

A paper by Professor H. C. Adams, read before the Society of Naval Architects and Marine Engineers in November, 1938, gave the results of model rolling experiments on the old warships Inconstant and Sultan. Each of the models had a smaller extinction than the corresponding ship. Since the greater damping on the ship was borne out by the result of the Nubian trials, it was clear that further investigation was called for. As a first action, the model was fitted with shaft brackets, shafts, propellers, and rudder, in addition to bilge keels. With these added, there was an increase in extinction at 7½ deg. of about 20 per cent., as can be seen from Figs. 6 and 7, opposite. Curve *a* is that for the ship, H.M.S. Nubian, in 32 ft. of water. Curves *b*, *c*, *d* and *e*, respectively, are for the Nubian model, complete with appendages, propellers and bilge keels, in water corresponding to 32 ft. for the ship; in deep water; without appendages, but with bilge keels; and for the naked model. The model extinction was still less than that of the ship. As a further step, tests were carried out in shallow water, the false bottom of the tank being adjusted to give the same depth to scale as in the basin in which the rolling tests on the ship were carried out, namely, 32 ft. These experiments show 8 per cent. greater damping effect at 7½ deg., but this is not sufficient to explain the difference as compared with the ship. Tests were then carried out with the model surface artificially roughened by applying fine shingle passed through a sieve of $\frac{1}{10}$ in. mesh, heated to assure adhesion and, after application to the model, covered lightly with shellac as a fixing. The degree of roughening was such that the deduced skin-friction resistance was 2½ times that for smooth paraffin wax or varnish. Rolling experiments, carried out with the model under similar conditions of loading as in the smooth-surface condition, both with bilge keels on and bilge keels removed, showed very little difference in rolling extinction; generally, the differences were within the limits of accuracy of the experiments.

As a further check, experiments were made on models of two other ships, the still-water rolling characteristics of which were known. One, H.M.S. Vivien, was a destroyer completed in 1918, and the other, H.M.S. King George V, a battleship completed in 1912. Rolling trials on the former in harbour and at sea had been attended by the author about 15 years ago, and still-water rolling results were available with complete automatic records. The apparatus used included the delicate long-period pendulum of W. Froude,* in addition to the Haslar short-period pendulum, gyro roll recorder, and battens. A model, $\frac{1}{13}$ full size, was made in paraffin wax and tried under the same dynamic and loading conditions as the ship in both deep and shallow water. Trials of the King George V had been carried out in Portsmouth Harbour 26 years ago. On account of the size of the ship, it was impracticable to work up a roll by men running across the deck, and the method adopted was to train the guns to one side and run them in and out to synchronise with the rolling period of the ship, but at a phase difference of 90 deg. The model was 1/37·5 full size, and experiments were carried out in deep water and also in shallow water to a depth corresponding to 42 ft., as for the ship in Portsmouth Harbour. Results for these ships and their models are shown in Figs. 8 and 9, opposite. In Fig. 8, curve *a* relates to the ship in 33 ft. of water, and curve *b* to the model, with bilge keels but no other appendages, in a depth corresponding to 33 ft. Curves *a*, *b* and *c*, in Fig. 9, refer, respectively, to the ship in 42 ft. of water, and to the model, fitted with bilge keels and docking keels, in a depth corresponding to 42 ft., and in deep water. The rolling extinction was slightly less than that for the corresponding ship. Still-water rolling tests were only an incidental feature of the trials, and only three rolls were made in Vivien and one in King George V. It is possible, therefore, that the results are not so reliable as those obtained with Nubian. The damping effect in shallow water was greater than in deep water for the battleship model, but for the destroyer model the difference was negligible.

The Nubian trials included extinction tests with bilge keels removed from the model. The results show the comparatively small extinction of the naked model, namely, only about 20 per cent. of that when bilge keels are added. The damping effect of the bilge keels is the same as would be produced by a normal pressure of 5·1 lb. per square foot of area moving at 1 ft. per second. This is equivalent to about five times the pressure on a plane in a uniform stream. This excess is incidental to induced reaction on the hull and the hydrodynamic current at the bilge combined with the non-uniform motion and virtual mass. In King George V, the equivalent bilge-keel pressure is deduced to be 8·5 lb. per square foot. All the above figures relate to the ship with an initial angle of 5 deg. The differences in the equivalent unital pressure illustrate the difficulty in applying theoretical treatment to assess the quantitative damping effect. Another aspect of the effect of the bilge keels, as revealed in the experiments, is increase in the rolling period for the same condition of loading, radius of gyration, and stability. This confirms previous results. With the Nubian model, the increase in period was found to be 0·1 second, and in King George V, 0·18 second. The Vivien model was not tried without bilge keels.

(To be continued.)

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* Paper contributed to the *Transactions* of the Institution of Naval Architects. Abridged.

† See ENGINEERING, vol. 147, page 386 (1939).

* "Results of Some Rolling Experiments on Ship Models," by M. P. Payne, *Trans. I.N.A.*, vol. 66, page 46 (1924).

* "Description of an Instrument for Automatically Recording the Rolling of Ships," by W. Froude, *Trans. I.N.A.*, vol. 14, page 179 (1873).

ROLLING EXPERIMENTS WITH SHIPS AND MODELS.

(*For description see Opposite page.*)

Fig. 3.

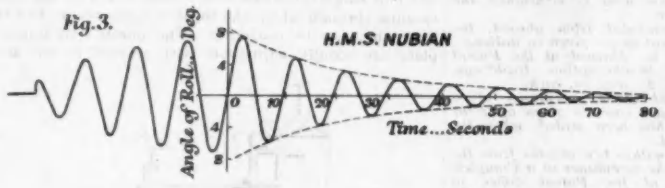


Fig. 4.

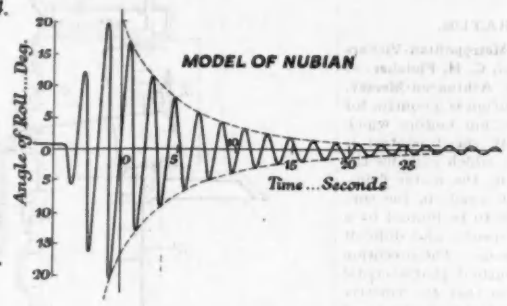


Fig. 5.

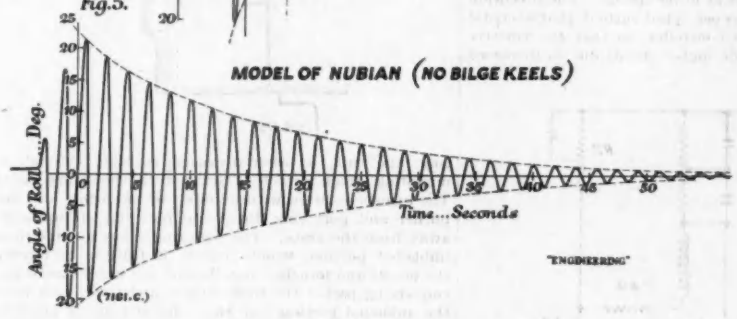
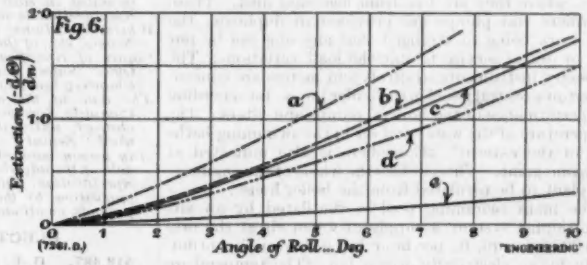


Fig. 6.



Displacement, 2,541 tons; wetted length, 364 ft.; metacentric height, 2·96 ft.; beam, 36 ft. 6 in.; rolling period, 9·8 seconds; draught forward, 10 ft. 8 in.; draught aft, 11 ft. 10 in.

Fig. 7.

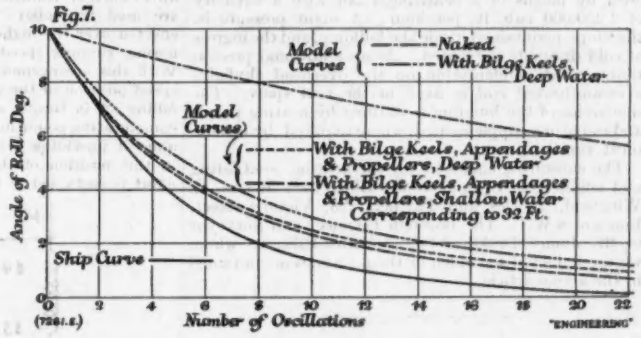
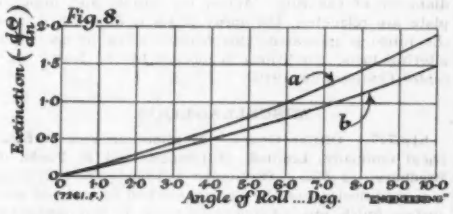
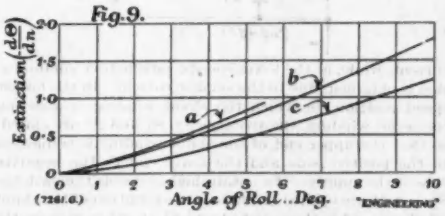


Fig. 8.



Displacement, 1,185 tons; wetted length, 309 ft.; metacentric height, 2·3 ft.; beam, 29 ft. 6 in.; rolling period, 9·1 seconds; draught forward, 7 ft. 1 in.; draught aft, 9 ft. 5 in.

Fig. 9.



Displacement, 25,550 tons; wetted length, 555 ft.; metacentric height, 5·53 ft.; beam, 89 ft.; rolling period, 14·7 seconds; draught forward, 29 ft. 3 in.; draught aft, 30 ft. 4 in.

THE DERBY BATHS OF THE BLACKPOOL CORPORATION.

THE Blackpool Corporation have recently completed an extensive indoor swimming bath which is situated on the east side of the Promenade, south of Warley-road, and is known as the Derby baths. The buildings, which occupy an area of 8,370 sq. yards, have been designed in modern style and contain two swimming pools, as well as a complete range of remedial baths. The main bath hall comprises a pool measuring 165 ft. long by 55 ft. wide, with a depth varying from 3 ft. to 16 ft., giving a capacity of 485,000 gallons. On its south side is a sun lounge, 144 ft. long by 25 ft. wide, with large sliding and opening casements glazed with Vita glass. It is surrounded on the other three sides by galleries, which are planned on the lines of an amphitheatre and have accommodation for 1,740 spectators. A learner's pool, measuring 30 ft. by 30 ft., with a capacity of 21,700 gallons, is situated on the sub-ground floor, and on two sides of this, slipper baths have been installed. The other accommodation includes a café, gymnasium, and offices for the superintendent and staff.

To provide the pools with the necessary supply of sea water, a pumping station has been erected on the Promenade. This is equipped with two vertical-spindle pumps, which are erected at the bottom of a cast-iron well, 9 ft. in diameter, and are each capable of delivering 500 gallons per minute against a head of 72 ft. Each pump is driven by a 18-h.p. Crompton-Parkinson motor, which is situated at floor level. These pumps are not self-priming and are, therefore, fitted with an injector primer, which is driven by a 1-h.p. motor. They pump the water through two 8-in. asbestos-cement pipes into two vibrated reinforced-concrete settling tanks, which are situated under the east end of the bath. Each of these tanks has a capacity of 60,000 gallons, and the sludge deposited in them is pumped off by another vertical-spindle pump, which has a capacity of 500 gallons per minute and is driven by a 6-h.p. motor. This pump, which, like the other pumps in the installation, was constructed by Messrs. The Pulsometer Engineering Company, Limited, Reading, delivers the sludge through one of the 8-in. asbestos-cement mains into a 15-in. sewer, whence it passes to the sea outfall at Gynn-square.

Owing to the large difference in capacity and to the fact that the two pools are at different levels, separate plant has been installed to deal with the water in each tank. As, however, both installations are the same in principle, it will be sufficient to describe that for the main pool. The sea water for the pool is drawn from the top of the settling tank through floating-arm strainers by two centrifugal pumps. These pumps are driven by 6·5-h.p. motors, which, like other motors in the installation, were constructed by Messrs. Crompton Parkinson, Limited, London, W.C.2. These pumps, shown in Fig. 3, on page 544, deliver water through pressure-type filters to the swimming pool, coagulation by chemical injection taking place *en route*. A view of one of the filter tanks and its agitator is given in Fig. 2, on the same page. Similarly, water for the showers and slipper baths is pumped through filter stages to tanks in the roof.

The water in the swimming pool is maintained at a constant standard of purity, irrespective of the bathing load, by a continuous system of filtration, aeration and sterilisation, and at a constant temperature by continuous circulation through calorifiers. The total water content of the large pool is completely purified once every three hours, the cycle of operations being as follows:—Water is drawn off through six outlet boxes with gratings, which are provided at intervals in the bottom of the pool. Two horizontal centrifugal pumps, each of which is driven by a 42-h.p. motor, are installed for this purpose. In addition, the surface water overflowing from the pool is collected from the surrounding scum channels and is passed to the filters for purification. It is then returned to the pump suction via a receiver tank, which automatically maintains a head of water on the suction line and precludes the possibility of air being drawn into the pumps. Before entering the suction inlets of the pumps, the water passes through large strainer boxes. These boxes are fitted with easily removable perforated cages, so that any large particles are prevented from fouling the pumps. The pumps deliver the water to twelve 9 ft. 6 in. diameter mechanical wash-type vertical pressure filters, the total area of which is 850 sq. ft., giving a filtration speed through the beds of 190 gallons per square foot per hour. Before entering the filters, the water is chemically treated with alumina and soda in an open-type coagulation plant, the chemical dosage for which is under accurate control.

After filtration the water passes through closed-type aerators where it is oxygenated by means of a positive injection of filtered air, which is fed to the aerator under pressure by an oil-free electrically-driven blower. After aeration the water is warmed to a temperature of from 75 deg. to 78 deg. F. by the circulation of a proportion of the flow over the tubes of steam-heated calorifiers. Finally, the water is delivered to the bath through sixteen inlets in the sides of the tank. Perforated spray pipes are also provided at intervals round the pool, just above the water line, through which water can be delivered by a 10-h.p. booster pump, a view of which appears in Fig. 1, on page 544, for display purposes. The water is sterilised on the chloramine system by the addition of ammonia and chlorine gases, in exact proportions, to the filtered-water mains.

The heat required for all purposes in the bath is generated in five gravity-feed magazine-type coke-fired low-pressure boilers, each of which has a capacity of 2,250,000 B.Th.U. per hour. The pipe work connecting the boilers is fitted with valves in such a way that any one unit or any combination of units can be put on the line to deal with the widely-varying loads. The coke is delivered from overhead bunkers, with a total capacity of about 70 tons, through guillotine chutes into two magazines which are built integral with each boiler. The total fuel storage provided on each boiler is 7 tons. Firing is automatic, and the only attention required is occasional clinkering and ash removal. The boilers have been specially designed to give smokeless combustion, and the natural draught is controlled automatically by means of special air and draught

doors. The top of the fuel bunker forms a gantry on which the calorifiers for the various services are installed, while the electrically-driven pumps for accelerating the water through the various heating and water-supply systems are accommodated in an adjoining room, where they are free from heat and dust. These calorifiers and pumps are provided in duplicate, the pipe work being so arranged that any one can be put into or out of service to suit the load variations. The necessary instruments, controls and meters are concentrated on a central panel in the boiler house, for recording the performance of the boilers, pumps and filters. The temperature of the water and air in the swimming baths and of the external atmosphere is also indicated at the same point. This enables the whole of the engineering plant to be regulated from the boiler house.

The main swimming pool is ventilated by an air-conditioning system, a supply of warm air at the rate of 3,000,000 cub. ft. per hour being delivered continuously by an electrically-driven fan. The temperature and humidity of the air is automatically controlled so as to prevent condensation from the pool collecting on the fabric. The vitiated air is withdrawn at a low level by means of a centrifugal fan with a capacity of 2,250,000 cub. ft. per hour. A slight pressure is, therefore, maintained inside the building, and the ingress of cold draughts prevented. As an additional precaution against condensation on the overhead skylight, a steam-heated coil is fixed in the roof space. The remainder of the building is warmed by heating panels and radiators, supplemented, where required, by mechanical ventilation.

The consulting engineers for the heating, ventilating and engineering equipment described were Messrs. E. Wingfield, Bowles and Partners, 28, Victoria-street, London, S.W.1. The Borough Engineer and Surveyor is Mr. James Drake, B.Sc., A.M.Inst.C.E., to whom we are indebted for much of the information contained in the above article.

CATALOGUES.

Lubrication of Jaw Crushers.—Messrs. Hadfields, Limited, East Hecla and Hecla Works, Sheffield, have sent us a folder describing their method of lubricating jaw crushers of the double-toggle type.

Non-Corroding Steels.—Messrs. Hadfields, Limited, East Hecla and Hecla Works, Sheffield, have also sent us a catalogue describing the properties of "Era" C.R. non-corroding steels, especially their resistance to heat and chemical attack.

Chilled Rolls.—From Messrs. Davy and United Engineering Company, Limited, Park Iron Works, Sheffield, we have received a leaflet describing the types of rolls manufactured by their subsidiary company, Messrs. Davy and United Roll Foundry, Limited, Billingham.

Turret Lathes.—Messrs. Gisholt Machine Company, Madison, Wisconsin, U.S.A., have sent us data sheets relating to performances on their turret lathes, which illustrate the actual tooling, as well as the sequence of operations and the time taken in machining typical jobs.

Paints and Compositions.—We have received a booklet, describing certain Lanoline paints and compositions, from Messrs. Croda, Limited, Croda Works, Rawcliffe Bridge, Goole, Yorks. These are the outcome of a report on research work, published in ENGINEERING, vol. 120, page 123 (1925).

Pumps, Motors and Generators.—We have received a set of recently issued brochures from Messrs. The Harland Engineering Company, Limited, Alloa, which describe their trailer fire pumps, "Spiroglide" multi-stage horizontal pumps, borehole and deepwell pumps, and also large direct-current motors and generators.

Motor-Car Trailers.—We have received from Mr. B. Dixon-Bate, Bridge Works, Chester, illustrated leaflets describing new models of trailers now in course of production and suitable for A.R.P. purposes. These are additional to the peace-time range of trailers for luggage, and caravan chassis, which is being maintained as far as possible.

Turret-Lathe Equipment.—A useful catalogue, with illustrations of tools designed for use with turret lathes, manufactured by the United States firm of Messrs. Bardons and Oliver, has reached us from Messrs. Broadway Engineering Company, Limited, Carlisle-road, Hendon, London, N.W.9, who are sole agents in this country.

High-Duty Bearings.—Messrs. Wellworthy Piston Rings, Limited, Lymington, Hampshire, have the exclusive right to manufacture bearings from the material now known as "Hiduminium," produced by the combined research staffs of Messrs. Rolls-Royce, Limited, and Messrs. High Duty Alloys, Limited. A booklet received from the last-named firm describes the properties and characteristics of the alloy R.R.A.C.9, used in highly-loaded bearings.

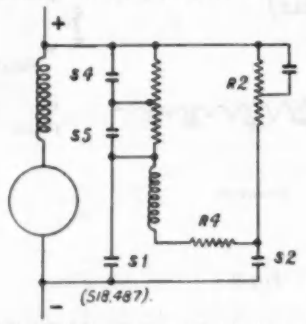
"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.
Where inventions are communicated from abroad, the Names, etc., of the Communicators are given in italics.
Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. *each.*
The date of the advertisement of the acceptance of a Complete Specification in each case, is given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.
Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

ELECTRICAL APPARATUS.

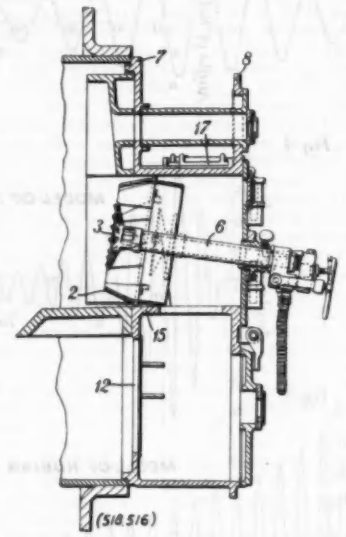
518,487. D.-C. Motor Control. Metropolitan-Vickers Electric Company, Limited, of London, G. H. Fletcher, of Sheffield, and H. K. Ramsden, of Ashton-on-Mersey. (5 *Figs.*) August 9, 1938.—The invention is a control for direct-current compound-wound traction motors which are used in trolley 'buses. Usually speed control is effected over the higher speed range, which includes the normal running speeds, by weakening the motor fields. With this arrangement the range of speeds in the top-speed position of the controller tends to be limited by a falling off in torque at the higher speeds, and difficult commutating conditions at lower speeds. The invention aims at providing a steeper speed-current characteristic in this position of the controller, so that the tractive effort is sustained at the higher speeds due to increased



current, while, at the lower speeds, satisfactory commutation is obtained, due to the smaller current. In the lowest speed position, in which the shunt winding is assisting the series winding, the switches S2, S4 and S5 are closed, so that the upper end of the shunt winding is connected to the positive side and the lower end to the negative side of the supply. To obtain higher speeds the switches S4 and S5 are opened to reduce the excitation of the shunt winding. S2 is then opened and S1 closed to reverse the connections of the shunt winding. The connection to the positive side of the supply is then through the resistances R4 and R2, and higher speeds still are obtained by cutting out a section of the resistance R2 to strengthen the shunt excitation. The resistance R4 is a small resistance which adjusts the value of the shunt resistance so as to permit the use of a standard winding when this is not otherwise possible. (*Accepted February* 28, 1940.)

STEAM ENGINES, BOILERS, ETC.

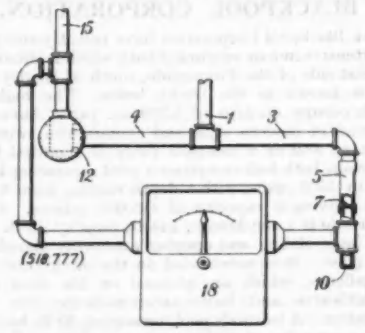
518,516. Furnace Front for Cylindrical Boilers. Babcock and Wilcox, Limited, of London, E.C.4, and A. R. W. Richardson, of London. (4 *Figs.*). July 28, 1938.—The object of the invention is to improve the combustion conditions in the relatively restricted space of a cylindrical boiler furnace at different rates of firing. The furnace front for a flue tube of a Scotch marine or Lancashire boiler consists of a burner nozzle operating by mechanical atomisation, a bladed port ring 2 surrounding the nozzle, and an impeller plate 3, the port ring and impeller plate being vaned to cause rotation in the same direction of the air entering the furnace. The impeller plate is carried by a tube 6, which also carries the oil burner barrel. The surface of the impeller plate is conical, with its base towards the furnace, and its vanes discharge air with greater rotation than the vanes of the port ring 2. The furnace front is circular and consists of inner and outer plates 7 and 8. Between the plates, below the horizontal centre line, is a circumferential wall, and forced draught enters between the plates above this level. The furnace front has two doors, the upper door carrying the tube 6 and the lower door serving as an ash door in the event of the furnace being coal-fired. An aperture 12 in the inner plate 7 also serves during coal firing to admit air beneath the grate, but during oil firing it is closed, and a plate which, during coal firing, occupies an aperture in a horizontal wall 15 between the two openings, is removed, so that air flows from the ash opening into the firing opening and thence past the burner into the furnace. Above the firing opening is a ported wall with a slide valve 17, which, during coal firing, regulates the flow of upper air to the furnace, but which, during oil firing, is fully open. Dampers regulate the flow of air to the ash opening, and their operating handle has a projection which moves in front of the firing door and prevents it from opening unless the dampers are closed. The port ring 2 is integral with a plate which fits the firing opening through which the furnace, after removal of the port ring, can be coal-fired. The nozzle and impeller plate are axially adjustable with respect to the port



ring, the tube 6 being arranged to slide through a mounting block, which is secured to the firing door. The furnace is fitted with a grate for coal firing, and the burner and port ring direct the fuel and air upwards away from the grate. The port ring 2 has a cylindrical unbladed portion, which renders it feasible to retract the nozzle and impeller plate behind the wider end of the converging part. The total length of the port ring with the unbladed portion is of the order of half the greatest diameter of the ring. When the nozzle and impeller plate are retracted, the spray angle is diminished, and the range is increased, this feature being of use when altering firing conditions according to the load. (*Accepted February* 29, 1940.)

MISCELLANEOUS.

518,777. Orifice Gauge. Metropolitan-Vickers Electrical Company, Limited, of London, and R. Poole, of Bredbury. (2 *Figs.*) September 1, 1938.—The invention is a modification of the known method of gauging size, surface finish, etc., of repetition work by comparing the leakage of air past the work with the leakage past a standard. The duct 1 from a compressed-air supply divides into ducts 3 and 4 respectively. The duct 3 is connected by a detachable tube 5 with an orifice 7 of known size. Beyond this orifice the circuit branches, one branch leading to a standard orifice 10 and the other to the inlet of a meter 18. The duct 4 is connected



through a calibrated needle valve 12 with the duct 15 and the outlet of the meter. The meter is a centre-zero instrument consisting of a pivoted vane in a passage-way between the inlet and outlet connections, which it does not completely obstruct. The duct 15 is connected to the measuring head, which includes the test orifice, the size of which is to be gauged. The arrangement resembles a Wheatstone-bridge circuit, the orifice 7 and the valve 12 offering a fixed and a variable resistance to the air flow to the standard orifice 10 and the test orifice, respectively, and the meter 18 detecting any unbalance of flow similarly to the galvanometer of a Wheatstone bridge. In operation, the needle valve 12 is adjusted to give a discharge equal to that of the orifice 7, so that deflection of the meter indicates the difference in size between the test and standard orifices. (*Accepted March* 7, 1940.)